Tappi

PUBLISHED BY THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY

JULY 1951

SOLID SUCCESS

THIS SIDE UP · STORE IN A COOL PLACE
HERCULES
DEFOAMER 4
PAT. APPLIED FOR
PAPER MAKERS CHEMICAL DEPARTMENT
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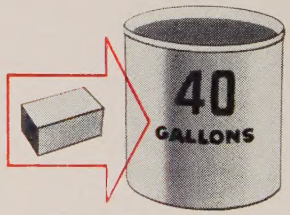

2½-lb. BRICK MAKES
40 GALLONS

NO DRUMS TO HANDLE

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PP51-5

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o more mail! Not a single scrap of paper to rite, type, or print on! Imagine what that ould mean to America . . . how it would affect very citizen . . . every profession and industry. Iost serious of all would be the threat to the ation's strength and security . . . when vital rrespondence, documents, orders, and infor- ation vanished from the scene! *Unthinkable?* on't take paper for granted. Anything so asic should be thought about . . . and safe- uarded. The free flow of communication rough our postal arteries depends on paper. *merica* depends on paper! Use it wisely . . . rotect its production . . . keep America strong.

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PROPERTIES OF THE PLIOLITE LATICES

	LATEX 150	LATEX 170	LATEX 190
Polymer Composition	Styrene-Butadiene	Styrene-Butadiene	Styrene-Butadiene
Particle Size (Angstrom Units)	800-1,000	800-1,000	800-1,000
Total Solids, %	33-39	33-39	33-39
pH Range	9.5-10.5	9.5-10.5	9.5-10.5
Surface Tension (dynes/cm)	30-40	30-40	30-40
Viscosity (cps)	35 max.	35 max.	35 max.
Specific Gravity (dried solids)	1.00	1.00	1.00
Stabilizer	Ammonium Soap	Ammonium Soap	Ammonium Soap
Antioxidant	None	Non-staining	None
Color	White	White	White
Mechanical Stability	Good	Good	Good
Storage Stability	Very Good	Very Good	Very Good
Ash Content, %	1.0	1.0	1.0
Film Formability	Fair	Good	Poor

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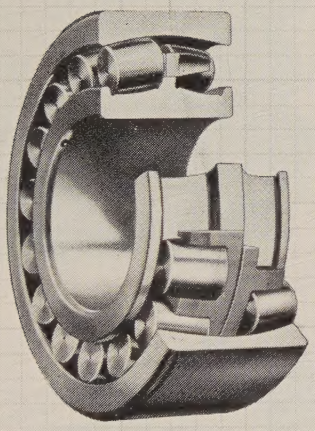
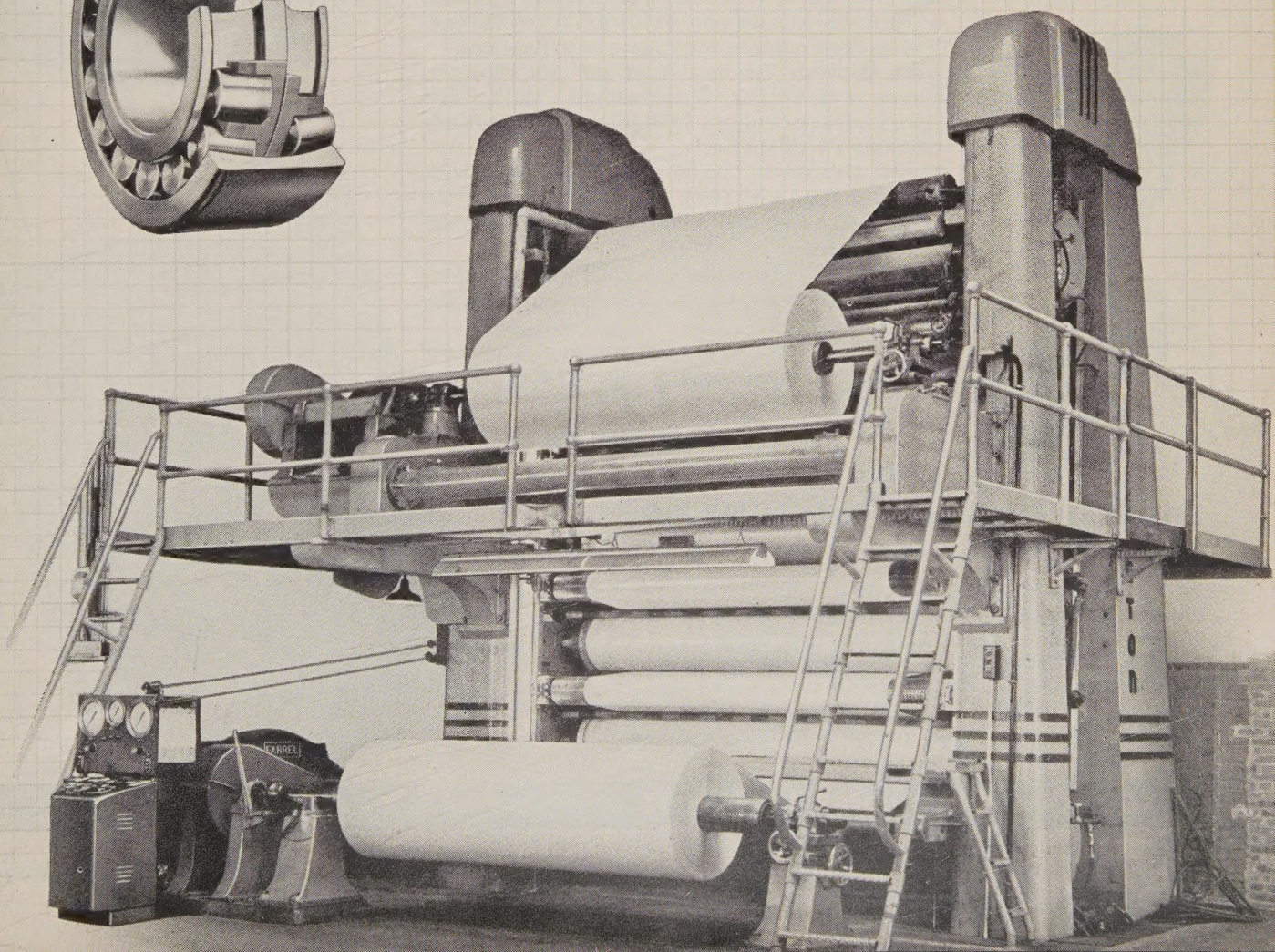
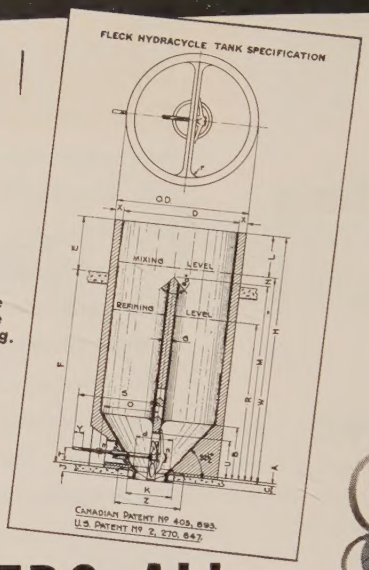


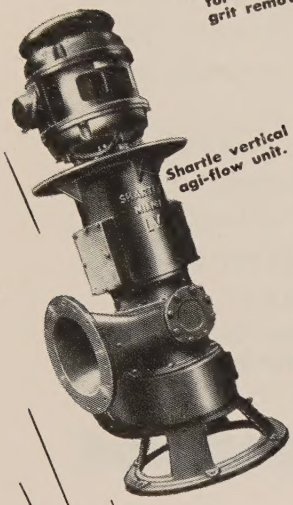


VERTICAL EQUIPMENT

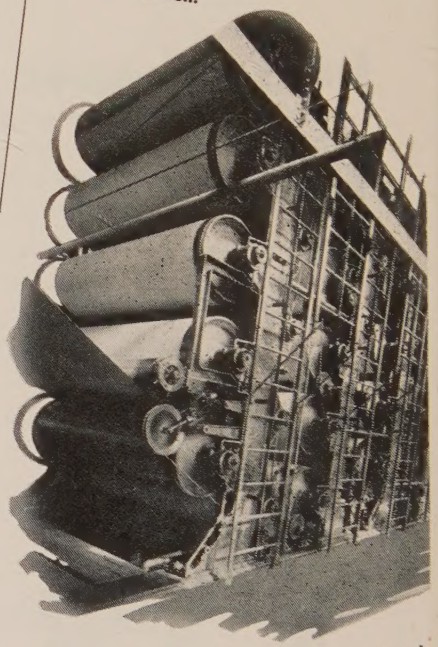
Shartle Hydraclone for sand and grit removal.



Fleck type Hydracycle tank drawing.



Shartle vertical agi-flow unit.



Black-Clawson vertical dryer section.

SPACE SAVERS ALL

Where space is at a premium, space saving equipment is bound to be considered—for instance:

Pumping. Water, white water and high density pumps are available at Shartles. All required capacities. Ideal not only for use in restricted areas but also in basements subject to flooding.

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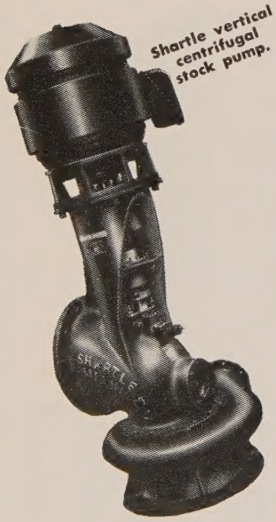
Stock Cleaning. The new sand and grit extractor, known as the Hydraclone, certainly is a vertical unit since it occupies only 18 sq. ft. of space immediately following a Hydrapulper.

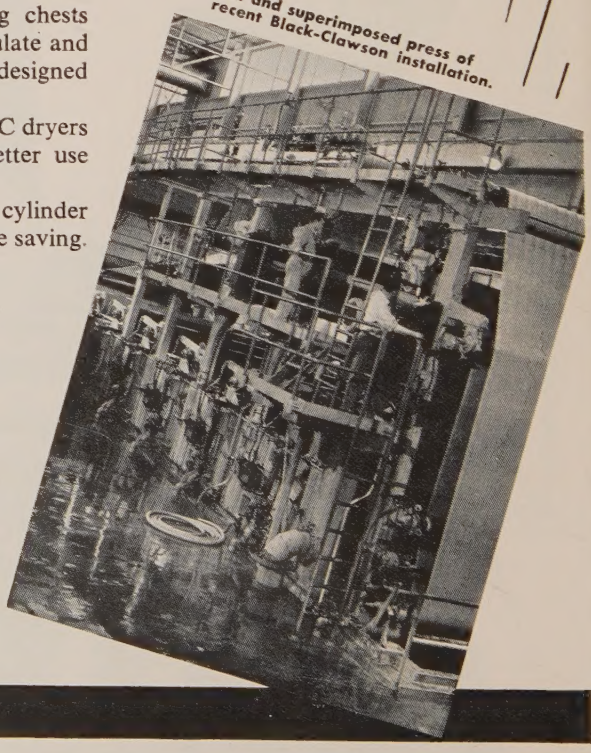
Chests. Hydracycle "tanks" and duo-cycling chests employed along with HYDRAFINERS to recirculate and HYDRAFINE stock are in reality specially designed vertical chests.

Drying. Every paper maker is familiar with B-C dryers arranged in vertical stacks—main reason better use of available space.

Forming. The superimposing of presses atop cylinder machine vats is a still further instance of space saving. A tremendous advantage in many a mill.



Shartle vertical centrifugal stock pump.



Vat and superimposed press of recent Black-Clawson installation.

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TECHNICAL ARTICLES

The Colorimetric Determination of Hydrogen Sulphide and Methyl Mercaptan in Sulphate Pulp Mill Effluents and of Sodium Sulphide in Black Liquor, *by R. H. Wright, M. A. Schoening, and A. M. Hayward* 289
Seam Adhesives for Multiwall Bags, *by K. M. Shold* 294
The Development of Wet Strength in Neoprene-Containing Papers, *by Gordon W. Wheeler, Alvin M. Borders, John W. Swanson, and George R. Sears* 297
A New Method of Detecting Slime in Pulp and Paper, *by Stanley J. Buckman and Virginia Henington* 302
An Optical Projection Method for Measuring Fiber Length, *by Thomas Fyfe* 306
The Sources of Wood Dirt in Unbleached Pulp, *by Carter A. Watson* 311
The Effects of Machine Head Speed and Specimen Span on Modulus of Rupture Values Obtained in Static Bending Tests of a Nominal $^{5}/_{32}$-Inch Douglas-Fir Hardboard, *by Hugh Wilcox* 314
Notes on Weight Factors for Fiber Microscopy, *by James d'A. Clark* .. 317
Ammonia-Base Sulphite Pulping Liquors—Their Preparation and Analysis, *by F. F. Bishop and J. F. Honstead* 318
Distribution of Starch in Clay Coatings, *by J. Wayne Dappen* 324
Photographic Standards for Dirt Control, *by William F. Cyrus* 335

DEPARTMENTS

Development Takes Cooperation, *by G. E. Field* ..... 12 A
First Corrugated Combining Conference ..... 20 A
Past, Present, and Future Design of Corrugated Combiners, *by Walter J. Goettsch* ..... 26 A
Sulphur, A *Chemical and Engineering News* Staff Report ..... 38 A
Association News and Events ..... 53 A
Personal Mention ..... 58 A
Local Section Activities ..... 76 A
The Use of Starch Adhesives on the Single Facer in the Manufacture of Corrugated Board, *by C. R. Vander Meulen* ..... 80 A
Operation of the Single Facer with Sodium Silicate, *by E. M. Hertzmark* ..... 86 A
Why a Statistician, *by Maynard S. Renner* ..... 92 A
The Trist Paper Coating System, *by A. Ronald Trist* ..... 96 A
Recent Books ..... 100 A
Employment Service ..... 102 A
Instrumentation Studies LXIII. Erasability of Paper. III Progress Report on a Study of Erasability 2, *by W. A. Wink, N. J. Beckman, and W. P. Raney* ..... 103 A
TAPPI Standards
Standard Drainage Time of Pulp for Insulating Board—Suggested Method T 1002 sm-51 ..... 120 A
Paper and Packaging Specifications ..... 122 A
Calendar of TAPPI Meetings ..... 123 A

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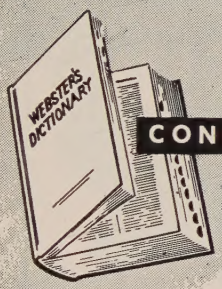
Connoisseurs OF BLACK LIQUOR



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one well versed in any subject; especially one who understands the details, techniques, or principles of a fine art.

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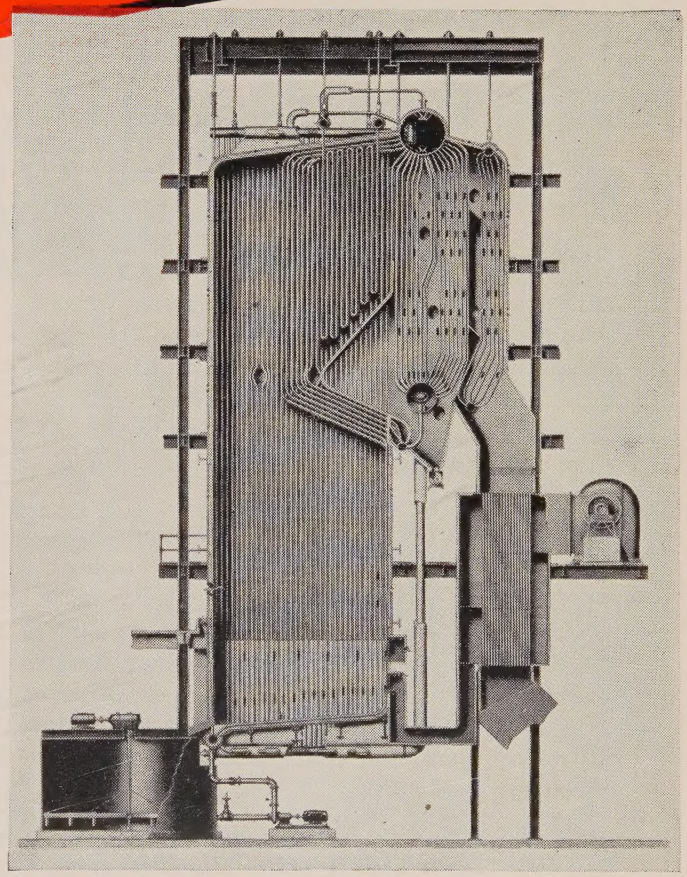
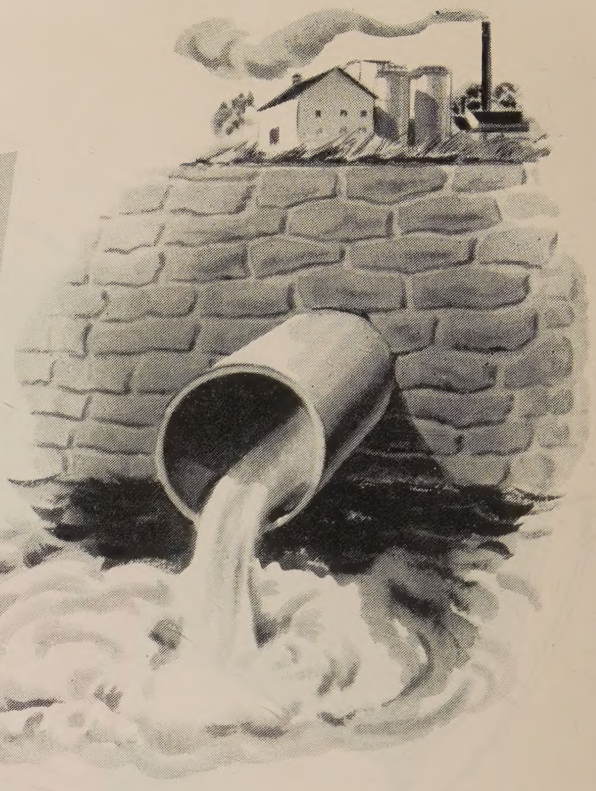


Typical B&W Black Liquor Recovery Unit.

BABCOCK & WILCOX

P-762

How to beat a legal "threat" on WASTE DISPOSAL



. . . and cut fibre and chemical losses!

WITH STATE AFTER STATE now imposing legal restrictions on industrial waste disposal, you may be faced with this problem quite suddenly. Only by starting to gather complete data now can you be prepared for necessary action when that time comes. And the same data will reveal the extent of your fibre and chemical losses in plant waste. (The Foxboro waste-sampling system gives a continuous sample always in proportion to effluent rate—thereby assuring an accurate analysis.)

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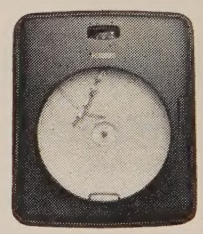
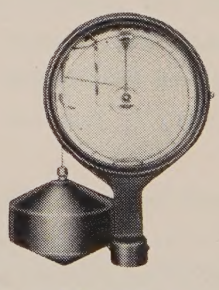
Send for a copy of "Waste Disposal Surveys". Write The Foxboro Company, 787 Neponset Ave., Foxboro, Mass., U. S. A.

TYPICAL FOXBORO INSTRUMENTS THAT LEAD TO BETTER WASTE DISPOSAL



The Model 40 . . . "The finest modern controller" . . . is the foundation of many outstanding Foxboro Waste Disposal Systems. It is used for the control of flow, pH, conductivity, temperature and other variables. Thousands are in use daily.



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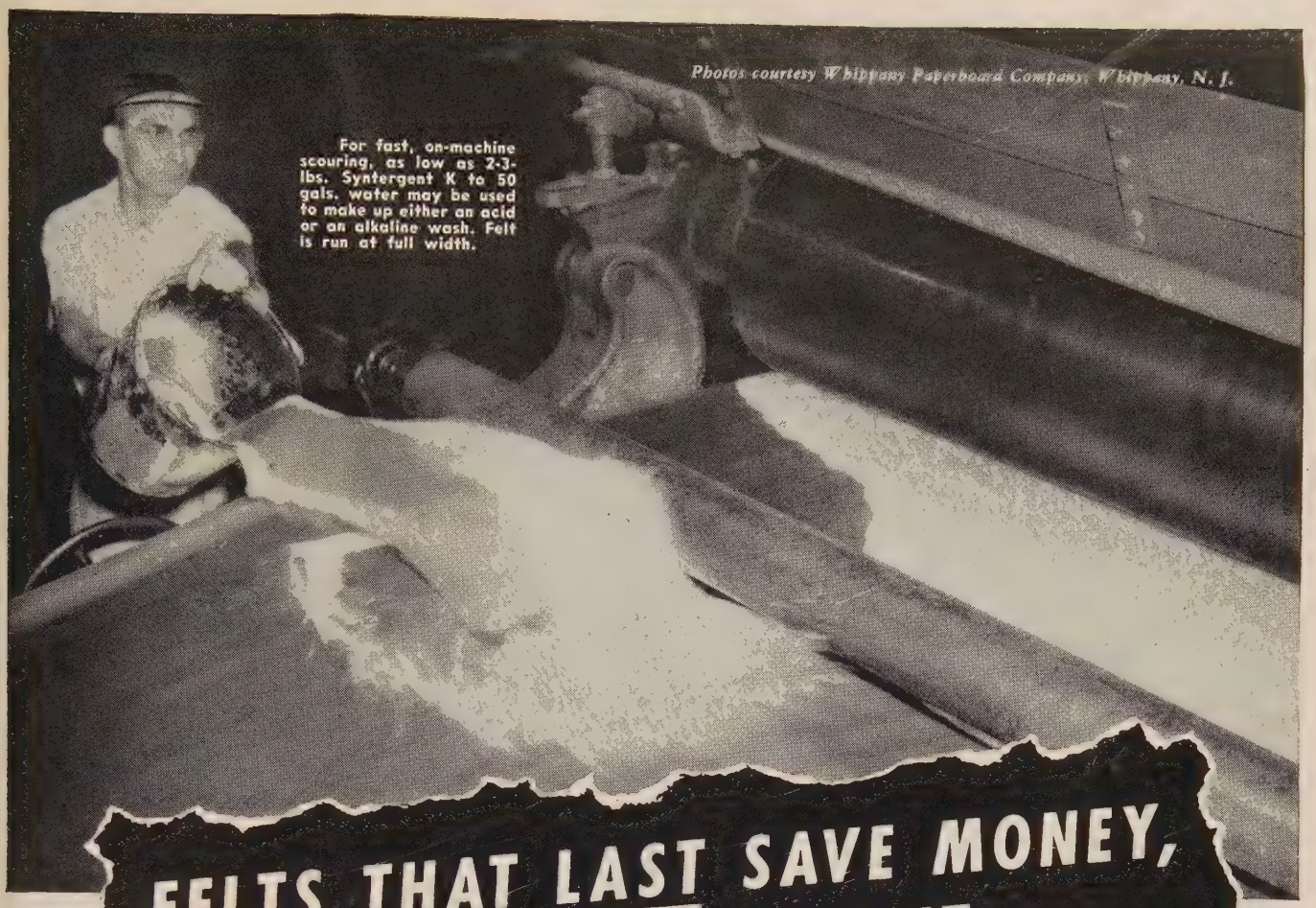

Photos courtesy Whippany Paperboard Company, Whippany, N. J.

For fast, on-machine scouring, as low as 2-3 lbs. Syntergent K to 50 gals. water may be used to make up either an acid or an alkaline wash. Felt is run at full width.

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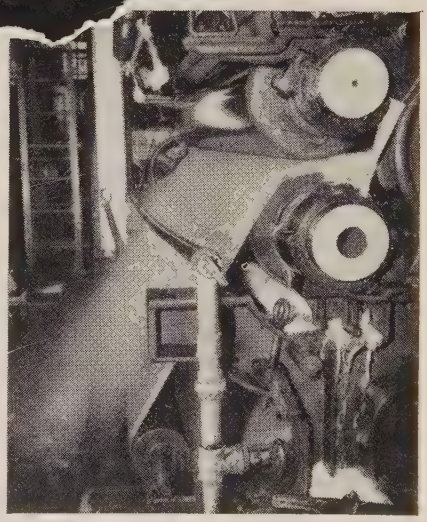
Syntergent K mixes readily with warm or cold water in all concentrations, to provide solutions which give copious and persistent lather and have excellent detergent and wetting characteristics. It is stable to both mild alkalis and acids, and thus can be used with either an alkaline or acid wash. It is likewise compatible with soap solutions.

You'll find Syntergent K very effective, also, for wetting out and conditioning brand new felts.

We shall be glad to supply you with formulas for *on*-machine and *off*-machine washing of press felts, wet felts and new felts. Our Technical Service Division stands ready to assist you *in your mill*, to make sure you obtain the best results as economically as possible.

Used in conjunction with soda ash, Syntergent K is ideal for cleaning vats, piping systems and screens during grade changes.



After running felt 10 - 15 minutes, fresh water showers carry away embedded soil in less than 5 minutes. The Syntergent K washes out freely and completely.

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Note: curling effected by 0 15 refiner

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J-C

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WORK WELL DONE SINCE '81

Development Takes Cooperation

G. E. FIELD

My subject for this evening is "Development Takes Cooperation." I do not believe that there is anyone here this evening who will disagree with this bald statement of fact. So, why the fuss? Why should I stand up here and waste half an hour to an hour of your time trying to talk you into something that you already believe? It's a good question, and I'm going to answer it by asking you one. Can any of you in this audience tonight honestly say that you have cooperated 100% with your fellow worker, whether he be in production, sales, development, or research? I think not. We are only human. We have our faults and prejudices developed over long years of training in specific fields. We hate people who disturb our established pattern of operations. If we are production people, we know that the research and development boys are crackpots, but if we are in research and development, we can't understand how the production personnel can be so stupid and unimaginative. And both groups believe that all members of the sales department are completely crazy, because they always want something that is absolutely impossible to make.

I still haven't told you a thing you don't already know, and I don't intend to do so. All that I'm going to do is remind you of the various and sundry means at your disposal for aiding cooperation. I'm going to reemphasize what cooperation means. I also want to illustrate, by example, the many misinterpretations applied to the word cooperation. Let's analyze that last statement first. Let's look at cooperation as the production man sees it. I'm not a pulp and paper man, and my examples may not apply to your specific industry, but you'll get the idea.

A development man comes to you with a new product which he wants to try out on plant equipment. You're very cooperative (you pride yourself on this) and you agree to the run. Then he starts outlining the operating conditions he will need on the machine, and you immediately forget that there ever was such a word as cooperation. You can't change the speed or the temperature. If you make certain changes, you will be hours or days getting back to smooth operation again.

Or, you may get the new operation started, and then notice a lot of changes that should be made. Do you suggest these changes? Why should you? You've been very cooperative, even letting him near your machine. Let him work out his own problems. The crackpot needs a little practical experience anyway.

Or, you start running into a lot of trouble. Scrap material is piling up. Conditions are being changed and improvements are being made, and in your heart you know that a lot more improvements could be made with an extra 1 or 2 hours' operation. However, your operations are all being fouled up, plus the fact that there's a limit to the amount of cooperation you can give, so you shut him down. Cooperation? How many similar incidents are in your memory, yet you felt that you were giving complete cooperation.

Now don't get me wrong, that I'm on the side of the development man. I've been in production work too long for that. What are some of the things the development man does that he misinterprets as cooperation. He goes to the production man to set up a trial run on a new process or product. The production man, in going over the details, notices a few weaknesses. He suggests some improvements based on his years of practical experience. The development man immediately takes a hard-nosed attitude and refuses to consider the changes. After all, it's his development, so why should a stupid production man know enough to make any improvements. He immediately starts throwing out highly technical terms explaining why these changes can't be made. However, he not only doesn't convince the production man, he also has changed that production man's interpretation of the word cooperation. You can be sure that the development man will get the benefit of that new interpretation the next time he has a production run to make.

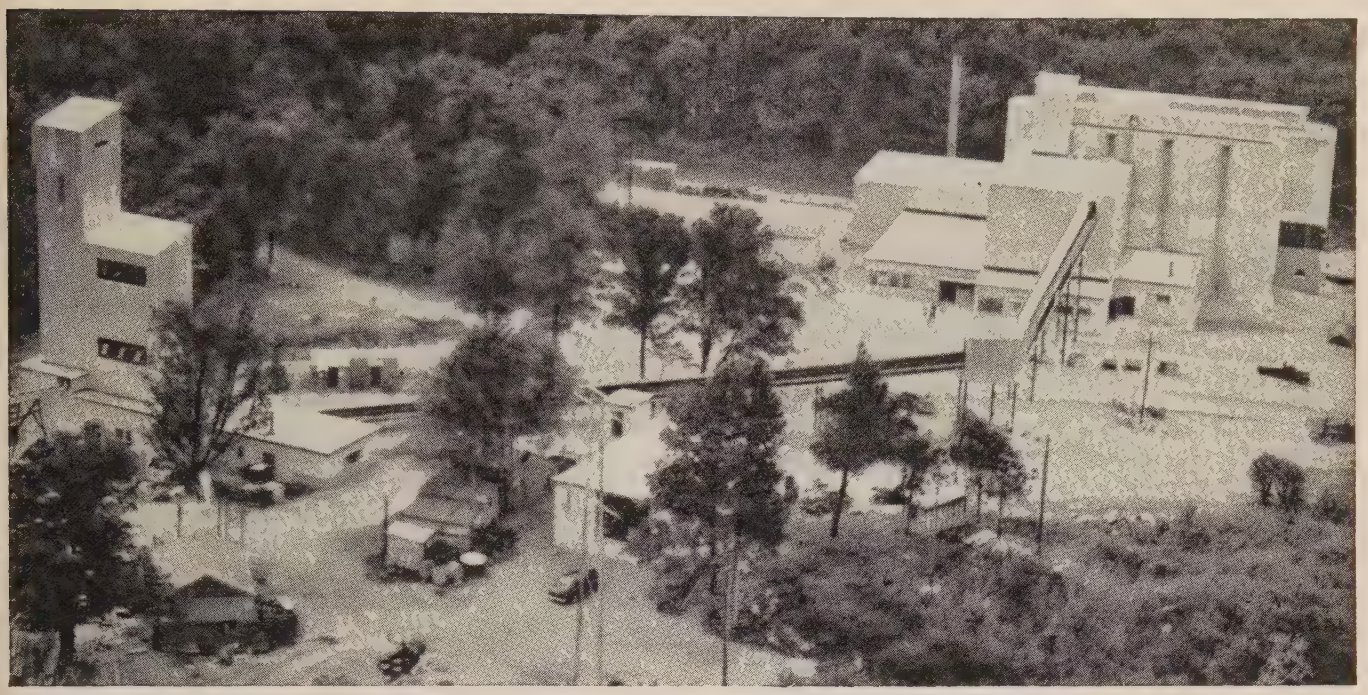
Another common mistake of the development man is the idea that he should be able to interrupt production for experimental runs at any time he sees fit. I think it goes without saying that that type of man has a hard row to hoe.

I believe a little clarification of terms would be apropos at this time. A development man is usually a technical man, whereas the production man may be technical or nontechnical. The point I want to make here is this—don't sell the nontechnical production man short. He has many advantages over the person with the technical training, not the least of which is his lack of technical know-how. His mind isn't cluttered up with technical "whys" and "wherefores." He has concentrated on studying his machine or operation, and he knows its idiosyncrasies, even when used on a new product. You'll never go wrong by at least asking his advice. I don't have to tell you people this, since I have had some experience with nontechnical operating personnel in the pulp and paper industry, and I know that you recognize the capabilities of these men. They are high-class operators, and can and do use good sound judgment in handling their problems.

During the war, I operated a synthetic rubber or GR-S plant in Louisville, Ky. We had developed a unique process of coagulating the rubber latex and dewatering and drying the rubber, based on papermaking techniques. We had six specially built 6-foot fourdriniers (small ones by your standards) designed to produce 45,000 tons of GR-S per year. We hired five fourdrinier machine tenders from the paper industry to form a nucleus for our operating crews. That their services were invaluable in getting that operation

G. E. Field, Technical Service Manager, Plastic Materials, B. F. Goodrich Chemical Co., Cleveland, Ohio.

ANOTHER VANDERBILT PRODUCT



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started, is a complete understatement of fact. The way they took over that operation, using a material completely unknown to them, was a pleasure to watch. After a few weeks, they had the operation fairly well stabilized at 1500 pounds per hour per machine. And then they started! Each of these men had been made shift foremen, and they tried to outdo the other men in total production. The rates kept going higher and higher. Pretty soon they started running out of latex, and then they began worrying the recovery department to pump through more latex. The recovery department started increasing the latex stripping rates to higher and higher figures in order to keep the drying department off its neck. Very soon they were running out of latex to strip, and started pressing the polymerization department for more material. They went to work and cut down on over-all cycles, reduced the lost time between charges, reduced charging time, and even reduced polymerization cycles. However, they were at the end of the line, and they finally had reduced everything to the bare minimum. As a result, from that time on, they were always behind the eight ball. They never did get ahead of the drying department except in rare cases when this department was shut down for major maintenance. Even these cases irked the drying department, so they proceeded to increase the production on individual machines. Another race got underway. Each shift would pick its pet machine of the 4 to 6 that were in operation, and try to break production records. The rates kept going up and up until one crew increased the production rate more than sixfold for an entire 8-hour shift. In the meantime, the average rates on all machines had gone to over fourfold the initial starting rate.

Did these nontechnical foremen do the whole job themselves? Not by a long shot! They got the ball rolling and they provided the incentive, but everyone of them worked closely with a technical development man. In fact, each of them eventually had his own pet development man, and they would plan their runs together. The foreman would say, "Can't you vary the coagulation system so that we can get a more porous crumb, or a more open sheet, so that the rubber will dry faster?" The development man would work out the process in the laboratory and then they would try it. If it looked good, they would wait for the most opportune time. They would even check the weather, because the rubber would dry faster when the weather conditions were just right. That operation of making GR-S is the most perfect example of complete cooperation between technical and nontechnical men on a development project that I have ever witnessed, or ever hope to witness again. To my mind, it is quite interesting that this story, based on the manufacture of synthetic rubber, an operation not even remotely connected with the pulp and paper industry, was made possible by six fourdrinier machines, and five machine tenders, all taken directly from the papermaking industry.

Now what was the major difference in the operation of the development project just cited and some of the other projects that did not progress so smoothly? I can name a lot of superficial reasons why this GR-S project developed as it did. The war and the dire need for GR-S for our armed services had its effect. The fact that all the men, from the general foreman down, were under 30 years of age at the start of our operations in 1942, had a bearing. But these are all superficial reasons. What was the fundamental fact that did the trick? It's an old idea, but its importance is overlooked in so many operations. What is it? *Selling!* Just as simple as that, but how often is it forgotten or misinterpreted. How often do we think of selling only in terms of a product and a customer.

The development man doesn't sell his ideas to the production man. He feels that the production man should realize that his new product or process is for the purpose of insuring his and the company's future. "If he is so stupid that he can't see that point, why should I waste my time arguing with him?" The production man feels that "if the crackpot can't see the value of my recommended changes, why should I waste my time?" And all that both of them need is a little bit of the questionable talents of the crazy man in the sales department. Did the foremen and technical men in that rubber plant sell their ideas to each other? You can bet they did! And not only 8 hours a day either. Many times they stayed over, anywhere from 1 to 3 hours, selling their ideas. Not a few of them were sold over a bar at the end of the 7–3, or 3–11 shift. In fact, we had a few complaints from the wives, particularly when their husbands didn't get home until 3:00 a.m., when going off duty at 11:00 p.m. I'm not saying that all that time was spent on selling production or development ideas, but at least a portion of it was. Neither am I advocating that a bar is always a good place to sell your ideas, but in some particularly tough cases, it has helped. The important point is that all of these men, whether production or development men, were selling all the time.

This selling of ideas requires the same contributing factors that help to sell a product. Not the least of these is enthusiasm. Of all the factors that add up to good selling, enthusiasm is the most contagious. If you are enthusiastic about your ideas, you'll do a fair job of selling, regardless of how poor you are in the other selling fundamentals. Another prime requisite is persistence. Never give up!

Let's take a look at another type of cooperation that has paid huge dividends and where the "selling" of ideas to obtain cooperation on a development project is a little more obvious. I'm referring to the selling of a product to a potential customer. In almost all cases, particularly in the selling of new raw materials to a processor, development of some type or another is involved. In selling of this kind, there must be complete cooperation on the necessary development, or you are not going to sell your material. Does the successful salesman merely try to sell his product to the customer? Definitely not! He sells the customer ideas! He makes him interested, enthusiastic. He gets him to want to try out the material that is being offered. It's a standard sales practice, as old as the hills. Why can't the development and production men within an organization try the same principles that make a good salesman. Why can't they see that the same principles that make for good salesmanship also enable them to obtain the fullest cooperation on development projects. Maybe the answer is that if they were good salesmen, they would be in the sales

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department and not in production or development. Perhaps it takes a certain type for each job, and if you expect too much of the salesman's or production man's attributes in a development man, he may not be a top-notch man in his chosen field. There is no doubt that you must put a man in a field for which he is best fitted. However, I do believe that anyone, regardless of his inclinations, can and should learn a little of the fundamentals of salesmanship, and he should also be shown the advantages of using these fundamentals in his everyday work. He may never, and probably will not become a top-notch salesman, but even a little training along these lines will certainly smooth down many a rough spot in his path.

In many types of development work, the customer may actually do a selling job on the supplier in order to get the cooperation necessary to solve a particularly tough development job. We have just completed a cooperative development program with a customer that took 4 years. During that period, the customer did a tremendous selling job on us in order to keep our interest alive in the project. However, it has paid off, and they are now going into large-scale production on the item. If they hadn't really sold us on the idea and kept selling us, we would have given up 3 years ago. That took real selling, and I know, because I was on the receiving end of most of it.

Some industries, particularly those that have been in business for a long time on a fairly standard item, require a lot more selling effort than others. The paper industry is one that the plastics manufacturers have been working on for several years with little success, until fairly recently. It hasn't been entirely their fault, since it was difficult to show them the advantage of plastic materials as coatings, or substitutes, without extensive, and I might add, expensive, plant runs. Laboratory results might look beautiful, but there's a long hard road between the laboratory and plant production, as you people well know.

We have had many problems in selling plastics to your industry, but we've kept plugging away, taking advantage of those companies where the inherent interest was the liveliest. As fast as one problem was solved, ten more would take its place, but step by step we have been getting closer to the solution. It hasn't been easy, and quite frequently in the past we have been ready to throw in the sponge. A lot of selling was required, but through that selling we got cooperation, and through that cooperation we kept going ahead.

One thing you should always remember when you're on the receiving end of a selling talk which will require you to put out a lot of cooperation. The new product or process may result in an actual improvement in your operation. Although on the surface it looks like you are asking for a lot of headaches, you may actually benefit the most. I remember well when GR-S first started moving into the tire factories in large volume back in 1943. You never heard so much screaming as the processing departments of the various tire factories let out when they started getting the new rubber in really large volume. They wanted us to change everything in order to make it process like natural rubber. "It was impossible to keep production rates going at the required level." "Something had to be done at once or the whole military program would bog down." Well, it was impossible for the GR-S plants to make these changes, since that end of the rubber program would have then bogged down. So Rubber Reserve stuck to its guns and told the tire factories that they would have to make it work. Pretty soon the screaming subsided, and for the last couple of years before the end of the war, very little was heard about processing problems. But when you talked to any of the processing people, you would always get the comment, "We'll sure be glad when we get back to the good old natural rubber again." In 1946, natural rubber started coming back in large volume, and the screaming started all over again. "We can't use this stuff, it's not the same as we got before the war," and many other similar comments. What had happened was that GR-S had certain processing advantages over natural rubber which they didn't recognize at first, but which they capitalized on as they gradually changed their processing techniques. Then they tried to make natural rubber fit into this new processing technique and it just woulnd't do it. So it illustrates that just because something new won't work as well as the item it replaces, that doesn't mean that it never will work as well or better.

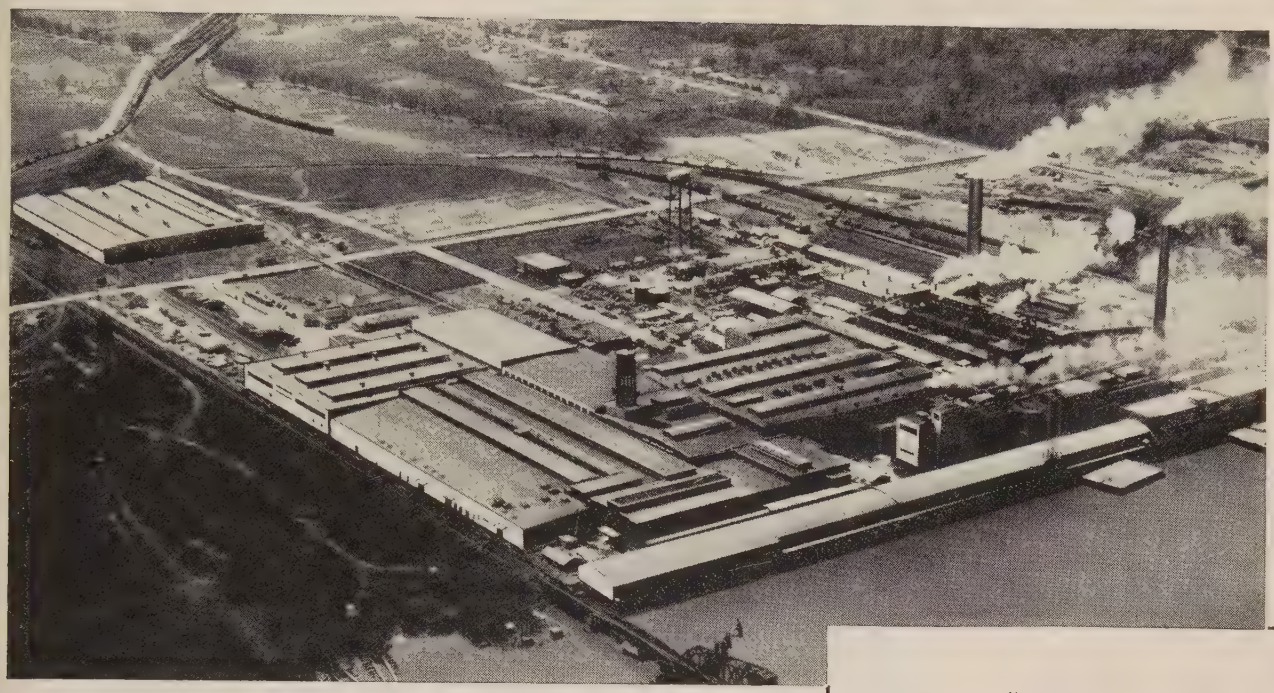
Let's summarize—What have I said?

1. Development does take cooperation.
2. Getting cooperation requires a selling job.
3. No one has to be in the sales department to do a selling job, if he puts his mind to it and really tries.

Nothing new, nothing fancy, nothing that you don't already know, but something that each and every one of you forget again and again.

PRESENTED at a meeting of the Lake Erie Section of TAPPI, Cleveland, Ohio, May 18, 1951.

Another C-E Recovery Unit for Union Bag & Paper Corporation



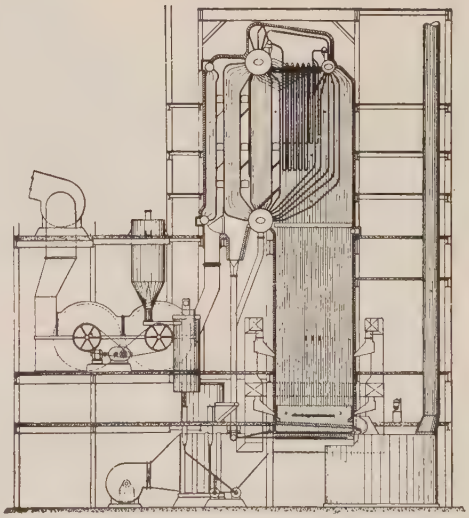
The Union Bag & Paper Corporation's mill at Savannah, Georgia, is the largest integrated pulp-to-container plant in the world.

In connection with its present expansion program, Union Bag has recently ordered another—its fourth—C-E Recovery Unit.

The new unit—like its immediate predecessor, in service since 1949—is of 350-ton capacity. It is designed to burn 1,050,000 pounds of black liquor solids per 24 hours and will produce steam at 425 psi and 725 F. Earlier C-E Recovery Units—of smaller capacity—have been in service at this mill since 1942 and 1944 respectively.

The C-E Recovery Unit's reputation for reliability, efficiency and operating economy is built on a sound basic design enhanced over the years by the addition of carefully developed, service-proved advantages. That its reputation is justified is evidenced by numerous repeat orders not alone from Union Bag & Paper Corporation but from several other prominent pulp and paper companies.

B-479



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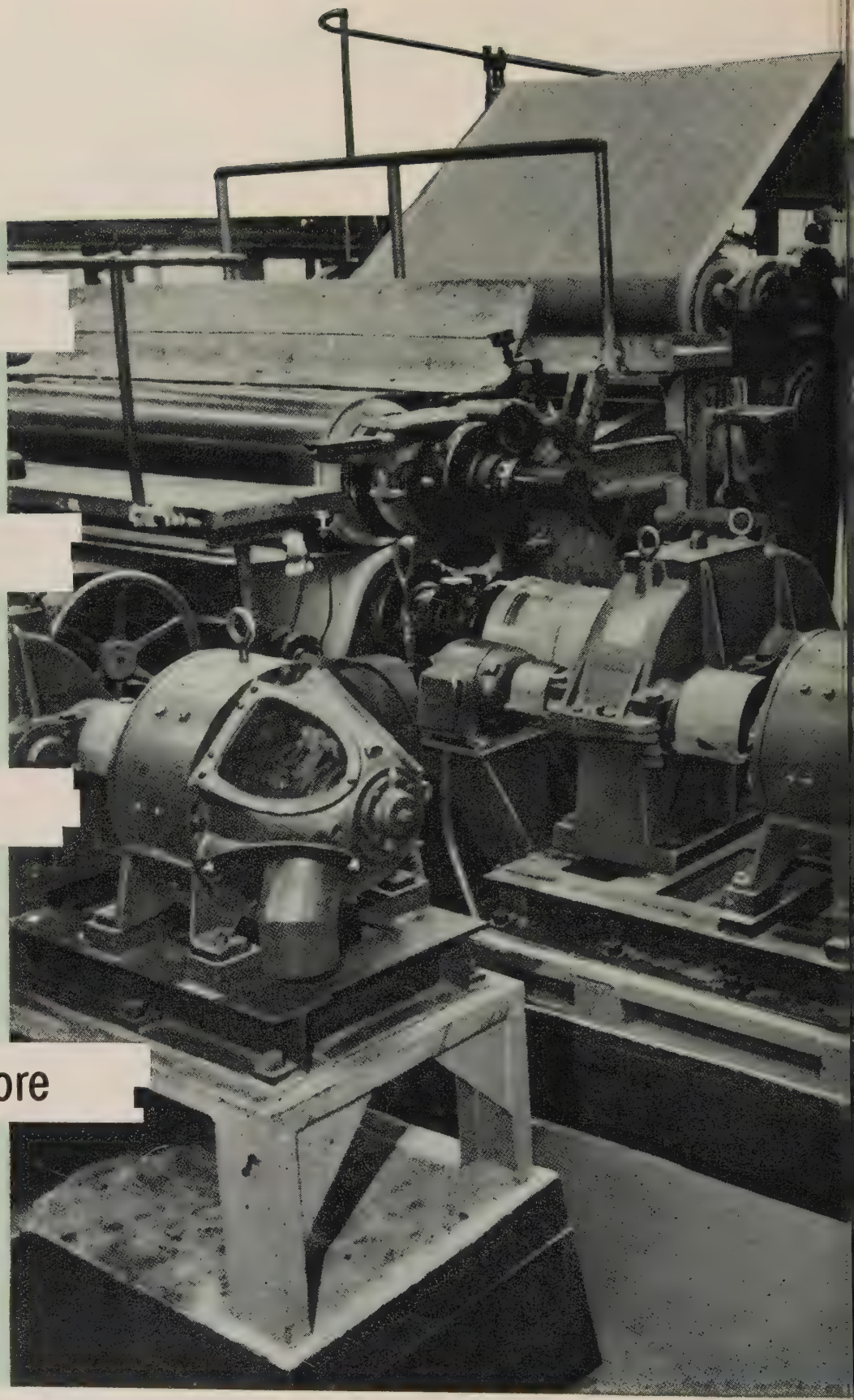

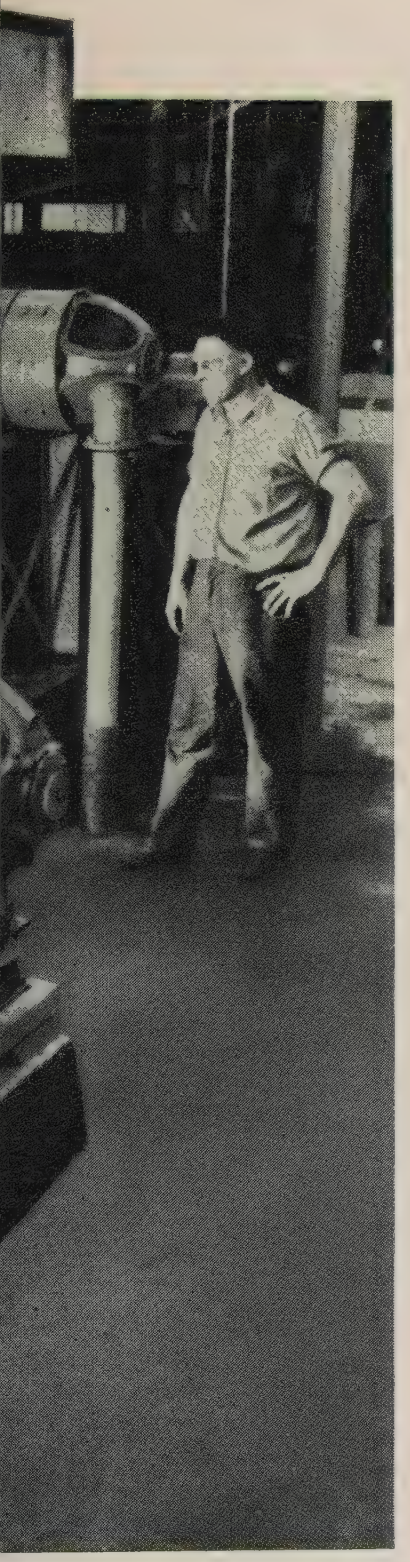

New wet-end drives save $25,000 per year

"We took the wet ends of our two machines off the line shaft and installed Westinghouse individual motor drives. In the first year of operation, these modern drives saved us approximately $25,000. They cut our felt costs 30%. They increased machine speed and boosted our production 10%." That's the statement of the superintendent of Morris Paper Mills, Morris, Illinois.

Felt Costs Cut 45c Per Ton

The new Westinghouse drives immediately produced major savings in felt costs. Now the felts don't drive the rolls and 10% lighter felts are used. Moreover, the felts last longer because they're not under tension. Worn felts are used that would have been worthless with the old drives. All told, savings in felts have averaged 45¢ per ton of paper produced.

Paper Quality Improved

With a motor driving each roll, the paper-making qualities of the felt are no longer compromised by the need for strength in the felt. Those now used have better water-removal qualities and make better paper. Also because there's no felt stretch, the fiber formation is not disturbed—which increases paper strength. Another important quality feature is the precise control of tension and draw between sections. There's no harmful stretching of the paper.

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The new drives practically run themselves. The speed of the wet end is automatically co-ordinated with the line shaft driving the dry end. Each motor has its own operator's cabinet for individual adjustment of tension and draw between sections.

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For more information on Wet End Auxiliary Drives, call your Westinghouse representative or write for Booklet B-3275. Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pennsylvania. J-94844

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FIRST CORRUGATED COMBINING CONFERENCE

Statler Hotel, Cleveland, Ohio, May 17–18, 1951

TAPPI'S Lake Erie Section played host to over two hundred enthusiastic delegates from eighteen different states at the First Corrugated Combining Conference held at the Statler Hotel in Cleveland on May 17 and 18.

One hundred and fifty of those attending started the two-day session Thursday afternoon by seeing how the Hankins Container Co. and the Robert Gair Co. Cleveland plants operated. Art Cheely, Quality Control Supervisor, acted as host at Hankins Container and H. A. Downing, Division manager, was host at Gair Cleveland Containers.

Bill Schoenberg and his committee spent a busy Friday morning registering the one hundred and fifty arrivals for the morning session. Lake Erie Chairman Lew Burnett of the Ohio Boxboard Co. welcomed the delegates and introduced Moderator F. D. Long, Technical Director of Container Corporation of America and Chairman of TAPPI'S Corrugated Containers Committee.

Introduction by F. D. Long

Members of Lake Erie Section of TAPPI and Friends: It gives me great pleasure to be able to welcome you to the Corrugated Combining Conference.

The Lake Erie Section has completed its probationary period as a geographical group and through persistence and diligence has proved that there is sufficient interest in this locality to justify a charter in the national organization of TAPPI.

This experience is one that is unique to the individuals who conceive and foster an organization. It was my privilege to be one of twelve individuals who organized the Chicago Professional Paper Group that is now the Chicago Section of TAPPI. A. E. Montgomery, one of our panel speakers today, was one of the prime movers in organizing the Chicago Section. We worked together on the constitution and one of our principal concerns was that we should write it in suitable fashion to meet the future requirements of National TAPPI. After our probationary period of 3 years, we were given our charter. It was my privilege to be chairman of the Section and to receive the charter and TAPPI insignia. I can assure you that it was a gratifying experience.

I wish to offer the congratulations of both the Chicago Section of TAPPI and my personal felicitations on being eligible for national recognition by TAPPI. Your record has been good and has every possibility of growing.

A year and a half ago, a group of individuals interested in corrugated problems met with R. G. Macdonald, our TAPPI secretary, to discuss the possibility of organizing committees directed toward corrugated container problems. The decision

Luncheon group at the First Corrugated Combining Conference, Hotel Statler, Cleveland, Ohio, May 18, 1951

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IN CANADA: Chemical Developments of Canada Limited, Leaside, Toronto 17

was made to set up a TAPPI Corrugated Container Committee. Since that time, there has been a very definite growth of interest within the industry toward solving many problems of the corrugated container field.

Committees have been set up to cover the following phases of corrugated production problems:

Adhesives (Starch and Silicate)	L. S. Johnson and M. F. Knack
High and Low Corrugations	J. J. Koenig
Fingerlines	W. R. Tobin
Corrugator Roll Wear	G. G. Johnston
Heat and Moisture Control	H. T. Scordas
Taping	E. K. Whitner
Stitching	W. W. Marteny
Waste	Keith Max
Printing	M. L. Hamilton

The committees were faced with the problem of determining what phases of corrugated production were most troublesome to the industry. An adhesive questionnaire will be circulated about the first of June which will cover the activities of the high and low corrugations, fingerline, corrugator roll wear, and heat and moisture control committees. We hope that the response will be as complete as that of the adhesive questionnaire.

It is the privilege of the TAPPI Corrugated Container Committee to cooperate with the Lake Erie Section of TAPPI in jointly sponsoring the program today.

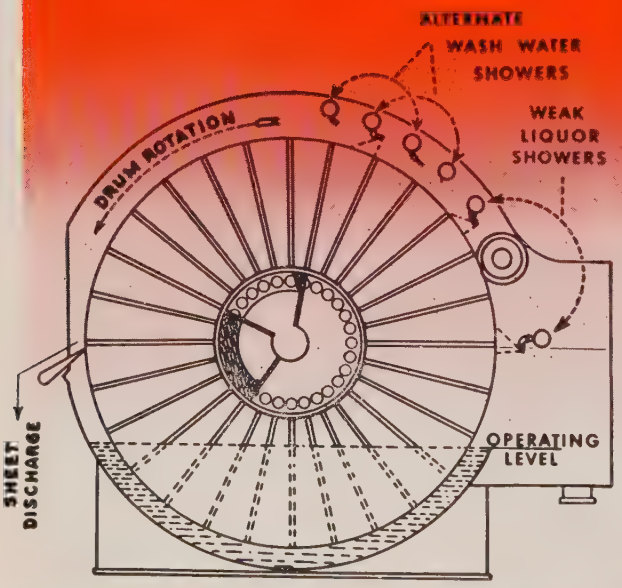
Qualities of Corrugated Board

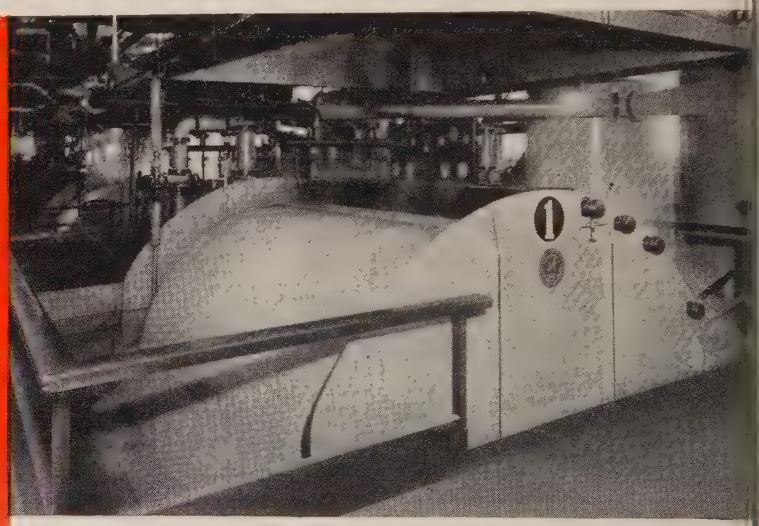
Mr. Long then introduced Carleton Root of the Container Section Institute of Paper Chemistry, who delivered a paper entitled "Theoretical and Actual Qualities of Corrugated Board."

"The corrugated box industry has experienced such a rapid growth in the last half century that the technology of the industry has not been able to keep pace with production. The increased production capacity and the awakening of interest on the part of the producer and consumer have brought about greater emphasis on quality in recent years. This emphasis on quality has highlighted the need for basic information relative to raw materials, operations, and performance of corrugated containers.

Washes Sulfite Pulp – 2 stages on 1 drum

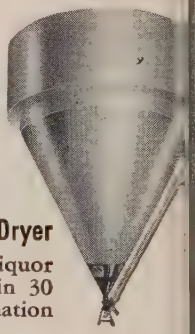
SWENSON-NYMAN PULP WASHER





Swenson-Nyman Pulp Washers of the type used for sulfite pulp

The diagram at left illustrates a sectional view of a Swenson-Nyman Pulp Washer, and the valve arrangement for maintaining separation of strong and weak sulfite liquors. Pulp emerges well washed at high consistency; with less dilution, thus reducing evaporation costs.



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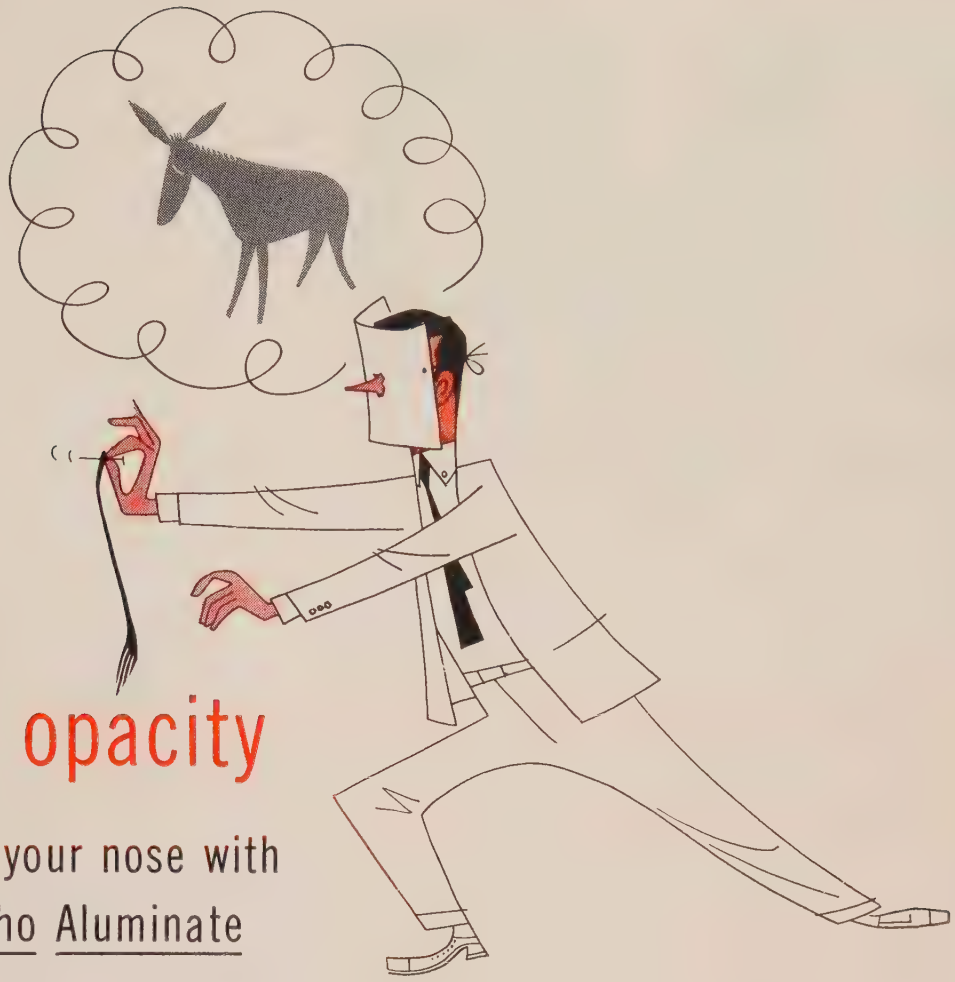

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Carleton Root, Institute of Paper Chemistry

F. D. Long, Container Corp. of America

"Regardless of the appropriateness of the bursting strength test as a means of estimating performance, the test must be considered because it is the only strength property specified in Rule 41 and therefore, is important if only from the standpoint of compliance with the rule. As a result of this, a great deal of information has been gathered which tends to indicate that the bursting strength is influenced primarily by the liners and only indirectly by the corrugating medium.

"Flat crush is considered to be an important property of corrugated board because of its influence on the stiffness of a box. In general, it may be said that flat crush is related to the number of flutes per foot with B-flute having the highest crush. As conventionally measured, the flat crush characteristics are independent of the liners, however, in actual use, the liners are contributing to crush resistance and therefore should be considered when some measure of box strength is to be made.

"The tube compression test is finding more favor as a means of evaluating the potential box compression qualities. In the tube test, a tube of the same dimensions as the box, but without the top and bottom flaps, is tested in compression and compared with the box compression. The tube compression might be considered as being the theoretical or maximum compression which could be expected for a particular board when made up into a box. In practice, this value is seldom, if ever, attained because of the influence of the scorelines.

"Although the conventional tests have been used for years as a means of evaluating container quality, they have not been particularly suitable for the design of new products or to insure the most efficient use of the present component materials. Engineers have been using basic engineering properties for years in the design of their structures such as bridges, airplanes, etc. Work which has been in progress at The Institute of Paper Chemistry for some time has indicated that fiberboard may be treated as an engineering material and that corrugated containers may be treated as engineering structures which lend themselves to treatment by engineering methods. It has been found possible to obtain modulus of elasticity of component materials and, together with other constants, use this information in the computations of maximum load of tubes. The calculated results agree with the test results within 6% in the majority of the cases tried. This work is currently being extended to boxes.

"Other properties of importance in the finished container are fatigue strength—the ability to withstand repeated shock loads, and creep such as occurs when boxes are stacked for extended periods in warehousing."

Q.: What physical test was used as the yardstick to measure component strength in the prediction of panel and tube compression strength?
A.: A tensile compression strength test was used, one which records the load-deflection curve.
Q.: Should a container 12 by 12 by 8 inches meet the same compression test as a 12 by 12 by 18-inch container?
A.: The deeper box will give the higher compression test.
Q.: In top-to-bottom panel compression tests was there any consideration given to position of fingerlines?
A.: No; on well-made board there will not be a preferential failure along a fingerline.
Q.: Can flat crush be predicted on the basis of corrugating medium ring stiffness?
A.: Not the ring stiffness test as conventionally run. It would have to be modified to get an accurate test of board deformation characteristics.
Q.: What is a recommended testing procedure to prevent leaning flat crush tests (caused by the test itself)?
A.: Platen movement may shift one of the facings, therefore platens must be rigid and parallel particularly for large areas. Platens can be roughened to prevent slippage and flutes oriented at right angles to the line of most platen movement.
Q.: What influence has testing speed on flat crush test?
A.: Viscoelastic materials will tend to give a higher test with higher testing speeds. Testing speed and application of load will depend on the rigidity of the material.
Q.: In your data relating to compressive load of tubes and containers, were the loads checked at failure or at a definite deflection?
A.: Loads were maximum peak loads that the tube or box would stand.
Q.: What is meant by liner restraint in the flat crush test?
A.: This pertains to a die compression test where tension of the liners comes into play resulting in 20 to 80% higher flat crush tests than with conventional testing procedure.
Q.: Will flat crush tests show which side (single face or double face) has the weakest arches?
A.: This is difficult to answer. One side will fail first conventionally.

Operating Problems in Corrugating

Mr. Root was followed by R. T. Cassidy, Vice-President of the Jackson Box Co., who discussed "Present Operating Problems and Future Hopes of a Corrugated Superintendent." Mr. Cassidy drew from his 12 years' experience in the production of corrugated containers during which time he served as superintendent and production manager. Many pieces of equipment now standard in the industry were tried out and proved in his plant. The ever-present problems of adhesion, roll wear, fingerlines, and high-low corrugations were brought out. Mr. Cassidy stressed the importance of good housekeeping and preventive maintenance as requisites for good operation. A well-engineered drying system is often the difference between success and failure. Future hopes outlined were speeds of 1000 feet per minute with automatic splicing equipment and side guides. Better designed corrugators to make it more convenient to operate at higher speeds have been the ultimate goal of every corrugator superintendent in the country.

Q.: Who manufactured the corrugating rolls with the new contour?
A.: Samuel Langston Co.
Q.: Who places "Repair Me" tags on the corrugating machinery?
A.: The head operator of the corrugator places the tag on the machine and forwards the stub to maintenance.
Q.: What effect does crown on corrugating rolls have on flat crush or compression tests?
A.: It should have no effect since a small corrugating roll with crown and a straight large corrugating roll are used. Pressure applied to the small corrugating roll tends to straighten out the roll so that there is no crown. Under normal loading the pressure is equal across the face of the roll.
Q.: What is the proper tooth contour on corrugating rolls for best performance?
A.: Proper tooth contour depends on many variables and would be difficult to discuss. Theoretically a pair of rolls run long enough would fit themselves. Corrugator operation is forming-molding rather than a tucking-folding operation. For maximum stiffness, the meshing parts must have a close fit. Ideally meshing parts would have equal uniform pressures on top, bottom, and sides. This can't be reached, however, since board must be pulled into the tooth. Even a slight degree of lean will decrease flat crush, therefore a tight fit more nearly approaches a perfect involute curve and the theoretical caliper of the board.

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THE RESINOUS PRODUCTS DIVISION

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Representatives in principal foreign countries

R. T. Cassidy, Jackson Box Co.

W. J. Goettsch, Samuel M. Langston Co.

Q.: Why are printing press impression cylinders made smaller than die cylinders? If the diameter ratio was 1–1, would compression tests be better?

A.: The die cylinder must be proper circumference to yield the proper result. A 1–1 ratio would repeat defects; too small a diameter would have a crushing action on the board.

Q.: What is the effect of pressure roll tension on board quality?

A.: A corrugator operator likes to operate with maximum tension because the corrugator operates better, however, excessive pressure may result in poor board.

Q.: What is an ideal operating schedule?

A.: An ideal operating schedule should allow time for preventative maintenance rather than more costly maintenance.

Q.: What is the most effective steam pressure for corrugators? Is better board made at 150 than 120 pounds?

A.: We would recommend a minimum of 150-pound steam and would like to have more since there is a greater volume of B.t.u.'s available without much rise in temperature. The limit on the corrugator roll steam joints and preheater is about 200 p.s.i.; steam plates about 175 p.s.i. With our present length of hot plates we have enough steam for more than 500 f.p.m.

Q.: What has been your experience with the operation of short- and long-fibered sheets on the same corrugator?

A.: Steam shower piping should be so arranged to provide interchangeable use of wet or dry steam for different sheets.

Q.: Can flutes be distorted by running a reground pressure roll with a regular corrugating roll?

A.: Grinding of pressure rolls should be merely a cleaning up process. If diameter is lost, it will be necessary to change gears in order to run at the same speed as the corrugating roll.

Q.: Is it feasible to control pressure on the pressure roll with a hydraulic device similar to the device being used to control small corrugating roll pressure?

A.: Yes; it is possible, however it must be put in capable hands as too much tension may score the board badly.

Theodore Ley, Universal Corrugated Box Machines, and W. P. Katz and Ed Taub of the Gibralter Corrugated Paper Co.

At luncheon in the Statler Grand Ball Room, the group was entertained by the Four-In-A-Chord Quartet, whose members did an admirable job on several old-time barbershop tunes. The group of young engineers led by Tom Wellman of du Pont's Grasselli Division are members of the Society of Barbershop Quartets.

Past, Present, and Future of Corrugators

The group gathered in the Euclid Room after lunch to hear Walter Goettsch, Vice-President of the Samuel Langston Co. discuss "Past, Present, and Future Design of Corrugated Combiners." Mr. Goettsch traced the beginnings of the corrugator back to 1870 with development in 1880 of single face—and in 1895 double face regular slotted containers, principally for express shipments in the New York area.

Past, Present, and Future Design of Corrugated Combiners

Walter Goettsch

THE heart of a corrugating unit is the single facer, and the most important element of the single facer is the pair of corrugating rolls which form the sheet.

If we trace back the origin of this part of our equipment we can go back to around 1870 at which time we find in use machines which comprise a pair of hollow fluted rolls, revolving in a pair of simple side frames. These rolls were usually heated by inserting into them heated rods or pokers. The rolls were turned by hand. These machines were used in some of the more progressive launderies to put ruffles into such things as curtains.

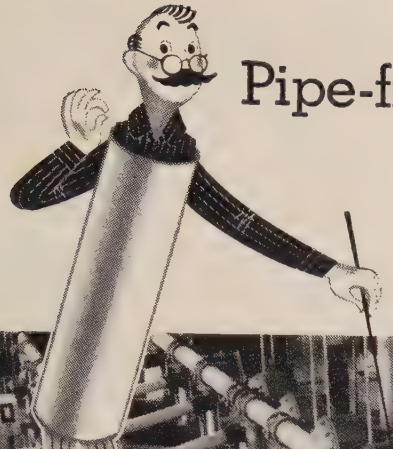
Soon thereafter very similar machines were being built and used to corrugate paper. The resultant unlined corrugated sheet found ready acceptance in the packaging of glassware, and along about 1880 we encounter single-face paper and soon after that double-face paper. By 1895 double-face regular slotted cartons had come into use, primarily for express shipments in New York City.

The machines in use at that time were very small, light, slow running, and simple affairs from about 24 to 36 inches in width. Apparently they were all very similar. The single facer was almost always operated independently of the double facer or combiner and comprised two and somewhat later three fluted rolls arranged in a vertical stack, heated either by gas flame or in some cases by steam at rather low pressures The corrugated sheet after passing through the rolls was led across a very simple adhesive applicator roll, permitted to drop down on the liner, and the combined web was then run over some heated plates and usually wound up into rolls for drying and seasoning. The third corrugating roll was added to the stack in an endeavor to apply more heat to the sheet and thus enable it to hold its fluted shape more firmly. In spite of very low operating speeds the big problem was that of making a single-face sheet in which there would be anything approximating a uniform number of corrugations per foot.

The double facers or combiners similarly were very simple and very crude, and the cut-off mechanism was usually a knife in the hands of the boy attending that part of the machine.

Soon after the turn of the century the corrugated shipping case begin to find increasing acceptance. Some of the basic patents which had been controlled by a very small group expired, and a number of new companies entered the field. The demand for larger corrugating machines capable of running at higher speeds stimulated the thinking of a new group of men and we entered a period which produced a considerable variety of machines which were all quite different.

They were all combination units in which the single facer and the double facer operated in combination with one another, all had cutoffs of one kind or another, but there the similarity ended.



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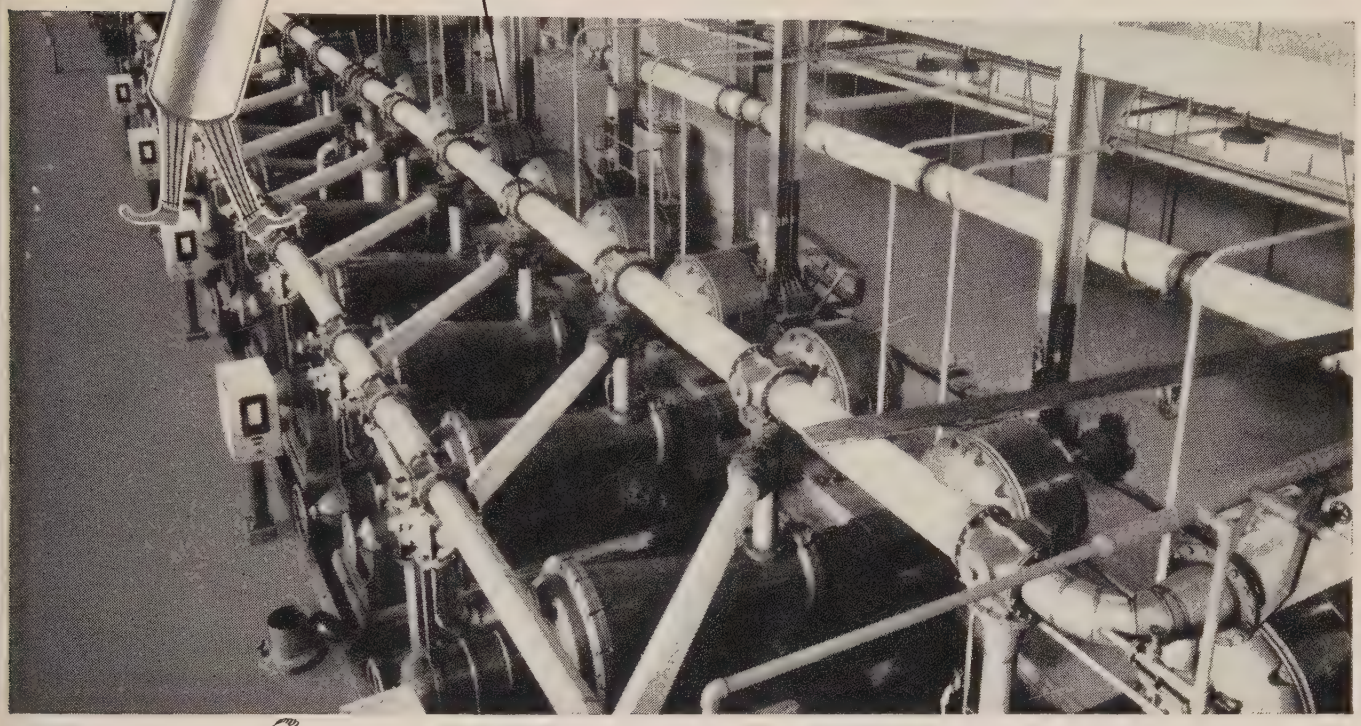

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Leon Hamilton, Container Corp. of America, and D. E. Turner, W. C. Beall, and D. K. Whitener, International Paper Co.

Time will not permit of a more careful review of the different machines of that day but it does seem desirable to touch on a few of them at least briefly. Incidentally, this is the period during which silicate of soda replaced the old-fashioned flour paste as the accepted adhesive, and the period during which operating speeds ranged from 40 to the then amazing speed of 100 lineal f.p.m.

There was the Raffel machine employing three fluted rolls with the corrugated member then carried across a simple adhesive applicator roll as we have described before. The corrugated member was dropped on the single-face liner and the web was then drawn across steam-heated plates by means of a caterpillar section made of steel slats about 3 inches wide. The finished single-face web was drawn back across the machine, the tips of the flutes now pointing downward and picking adhesive off another very simple adhesive applicator roll. The double-face liner was introduced from below, joined with the single-face web and both then drawn across another series of steam-heated plates again by means of a caterpillar section such as we have described. The cutoff on these earlier machines comprised a stationary blade against which a revolving or "fly" knife operated to chop rather than cut the sheet.

In the single-facer end of other units we see various attempts to produce a uniform or registered corrugation. John McPike developed and built a machine in which one of the two corrugating rolls was quite large in diameter. Adhesive was applied to the tips of the corrugated medium while still held in this large roll. The liner was then brought up against the corrugated medium and the large corrugating roll on a belt which hugged the large corrugating roll over an arc of possibly 90 to 100°. The M. D. Knowlton Co. built a machine in which the corrugated medium after passing between two small fluted rolls was deposited in a large fluted drum. The tips of the flutes here were cut down so that the corrugated medium projected out beyond the face of the drum slightly which facilitated applying adhesive without getting too much of it on the drum. The liner was then led around this drum and held under sufficient tension so that it could be bonded to the corrugated medium. The liner of course had to be a rather flat sheet and capable of running under considerable tension.

The real solution to this problem of a uniform or registered corrugation, however, was found to be the application of a pressure roll running in conjunction with two corrugated rolls. The first of these pressure roll-type single facers was built by J. T. Ferres about 1900. This had the two corrugating rolls and the pressure roll in a vertical arrangement with the adhesive applicator roll being brought in from one side. The machine had two-piece fingers or guides. Very shortly thereafter Sam Langston built pressure roll-type single facers but disposed the rolls in a more nearly horizontal arrangement which made it possible to position the adhesive applicator roll underneath the machine, and use one-piece fingers. Thus we have the true forerunner of today's machine. It is interesting to note that all the other types above referred to ceased to be built quite some years ago.

The single facer of today is basically nothing but a refinement of the single facer Sam Langston built almost 50 years ago.

As in the case of the single facer we find that the double facer similarly went through some very strange forms. Many machines were built with caterpillar sections of the type commented upon in connection with the Raffel machine. Quite a few of these used caterpillar sections to engage both the top and the bottom of the sheet with heat supplied from steam piping installed on the inside of these caterpillar arrangements both above and below the line of paper travel. Various means were used to drag the double-face sheet across the steam plates and to hold it in engagement therewith. In the Knowlton machine we note an ingenious arrangement of brushes. In the case of Swift machines for many years a series of cocoa mats interspersed with caterpillar sections was used.

Another solution involved the use of cotton belts much as we use them today. This solution was first discovered by Sam Langston when he built a double facer utilizing cotton belts in combination with heated steam plates in almost the same manner in which practically all double facers are built today. The first of these machines was designed, built, and patented by him in the period 1907 and 1908. About all that has been done since then is to improve this machine mechanically, and to lengthen it out for higher production. After the expiration of the basic patent this principle was adopted on all double facers, and it was in recognition of the importance of this invention that Sam Langston was awarded citation as a Modern Pioneer by the National Association of Manufacturers.

Again in the case of the cutoff we see a similar development. After trying out a great variety of different movements we note the emergence of the rotary cutoff involving two revolving heads driven so that the two cutting blades perform a shearing action on the continuously moving web with the blades traveling at exactly paper speed.

One of the very important developments without which present-day operating speeds and close limits of accuracy would be absolutely impossible was the continuous running mechanism. The first cutoffs offered to this industry which eliminated the very troublesome intermittently acting clutch and brake mechanisms were built by the Samuel Langston Co. during the depression years of the early thirties. The advantages of driving cutoffs continuously were so obvious and so great that the clutch and brake type cutoff ceased to be built within a period of very few years.

The rapid growth of the market for corrugated containers, especially subsequent to the famous Pridham Decision of April 6, 1914, brought many new companies into the field and demanded much additional equipment. The building of equipment, a function performed during the early stages mainly by the container manufacturers themselves, fell to an increasing extent to a small group of equipment builders, who sought constantly to outdo one another in the development of wider machines capable of higher speeds, lower labor costs, lower waste, better quality, etc. The container industry itself became more competitive and increasingly conscious of greater manufacturing efficiency and higher quality. New materials came into use such as starch adhesives, kraft liners, and other wood fiber sheets. New flute types, such as B and C entered the picture. All of these factors influenced and greatly stimulated the development of equipment.

Competitive pressure gradually forced the universal adoption of the basic design features embodied in the pressure roll single facer, the cotton belt double facer, and the continuous running cutoff. As we look over the machines built in recent

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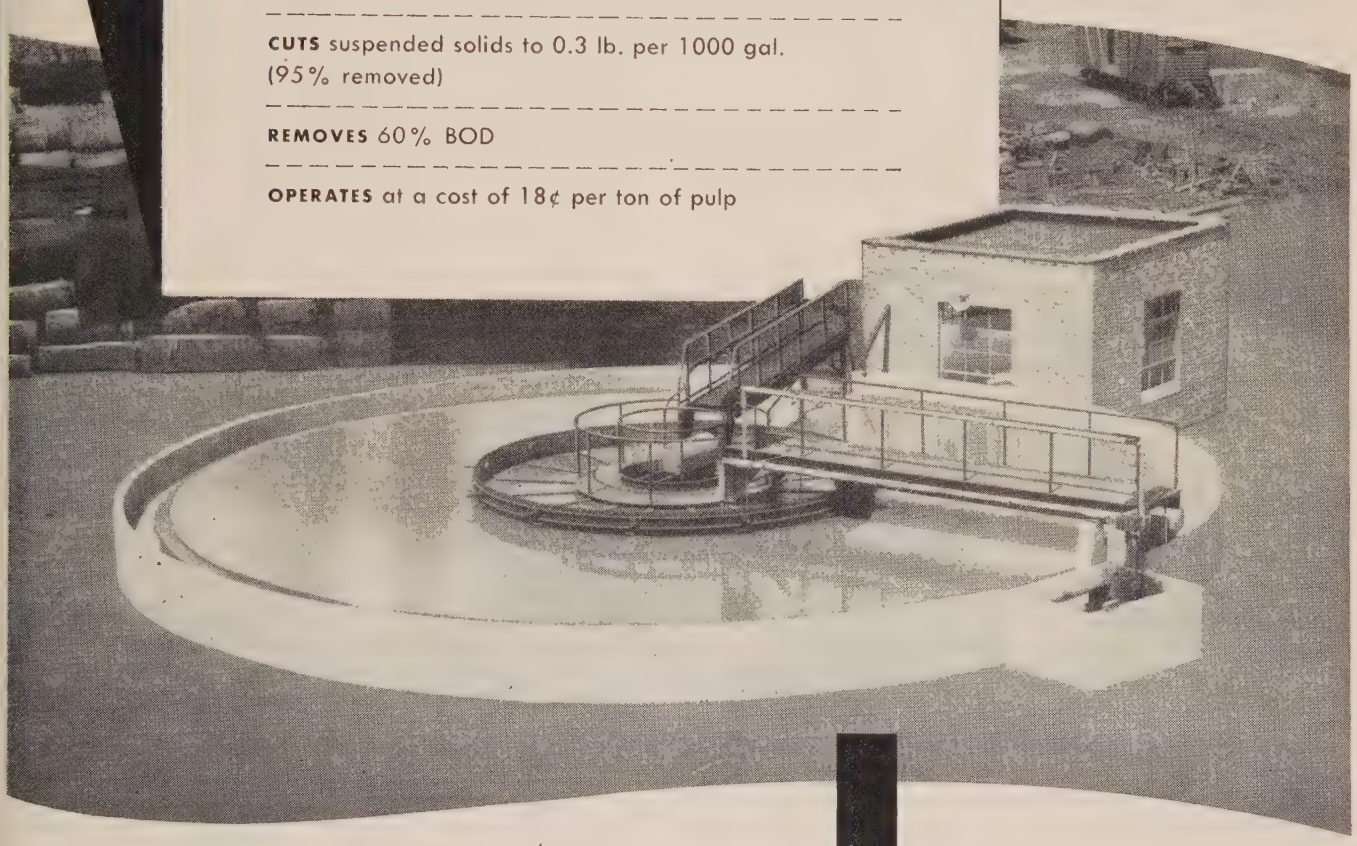

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years we note that in the basic principle of operation there are very few differences. Even such once controversial items as slitting and scoring attachments and double cutoffs which Sam Langston patented in 1916 have found universal acceptance.

At this point let us state, and state most emphatically, that there are many and important differences between the machines being offered by the still highly competitive machine builders. What we are pointing out is the very interesting fact of a very broad acceptance of the basic design features. The differences today rest mainly in refinements of design, quality of workmanship and materials, and field service, auxiliary apparatus, etc.

Let us now take a look at a typical modern corrugating unit. We note first of all that the machine is larger, and heavier in almost every respect. Whereas not so long ago the standard machine in the industry was the 63-inch machine, we now find the 85-inch machine in its place. We furthermore note a tendency to go to increasingly wider machines, 92, 96, 105, and up to 115 inches. The modern machine is somewhat longer; however, the increase in operating speed is proportionately greater. As against speeds of 200 feet formerly modern machines are now maintaining speeds of 500 f.p.m. and over.

Construction throughout embodies the improvements typical of modern industrial machinery such as heat-treated gears, most of them running completely enclosed in oil-tight cases, precision antifriction bearings, force-feed lubrication at the more important points, etc. The old bronze corrugating roll, frequently gas heated, has been replaced by heat-treated alloy steel corrugating rolls of a very much larger diameter. We note that constant speed motors, Reeves drives, clutches, chain and sprocket drives, etc., have been almost entirely eliminated. At the single facer a large variable-speed motor is coupled to the large corrugating roll by means of one heavy duty, simple worm drive running in oil. The adhesive mechanism here as at the double facer is driven by a separate motor running in synchronism with the main drive motor. The double facer also is driven by a large variable-speed motor. These variable-speed motors receive their power and control from heavy duty motor generator sets, usually located at some slight distance from the corrugating unit, wherever they can be best protected from heat, dust, and possible vibration.

Although the machine, running at 500 f.p.m., is consuming roll stock at a rapid rate, there are only two men in attendance at the front end of the machine. With a minimum of physical effort they push the rolls of paper into position adjacent to heavy duty shaftless stands, either on roller conveyor sections laid flush in the floor, or by means of a track and dolly system. Cone-shaped spindles carried on heavy arms enter the core opening of the roll and quickly raise it into running position. Web tension is regulated by simple hydraulic controls with gages registering brake tension, where formerly this was pure guesswork. Web alignment is by means of push buttons located conveniently at various spots on the machine.

The shaftless stands have not only reduced the number of men required, but by removing the arduous physical labor handling heavy shafts and other cumbersome apparatus, have eliminated the man with the strong back in favor of the man who can be chosen for his experience, intelligence, and judgment.

We note the large preheaters with adjustable idlers by means of which we can preheat the two liners as well as the single-face web, varying by means of convenient push-button control the amount of wrap which may be required. We note a fourth steam-heated drum, in this driven and operated in conjunction with a steaming device, serving to precondition, plasticize if you will, and prefeed the corrugating medium. This apparatus, known as the preconditioner, is one of the several features contributing not only to high speed but also to a higher level of quality. Here again push-button control of an adjustable idler permits of varying the amount of wrap. We note also that all of the splices are being made on the fly, an operation that is greatly facilitated by these four heated drums.

Now the single facer: all the way through it is a very much heavier machine. It has an entirely different sound to it and although its basic principles of operation have not changed, it has about as much resemblance to its protopype as a Strato-Cruiser or Constellation to the plane the Wright brothers flew at Kittyhawk. The multiplicity of levers and handwheels has been eliminated and instead we have push buttons located at convenient points. Corrugating and pressure rolls have been substantially increased in diameter and run in special antifriction bearings carefully selected for this particular duty. The adhesive mechanism which for many years comprised a transfer roll running in combination with a fountain roll has been replaced by a large combination fountain-applicator roll operating in conjunction with a doctor or metering roll. The adhesive film on the applicator roll is absolutely smooth and uniform without any tendency to bead or develop any other irregularities. On closer inspection we note a calibrated dial which indicates the clearance between the applicator roll and the large corrugating roll, and note further that this clearance is 0.015 of an inch. Here we find one of the few handwheels on the machine by means of which the operator can quickly and accurately regulate this clearance. All of us who have operated single facers know only too well that this is one of the most important adjustments on the machine. The machine that can run with a very close setting here will not only make better quality paper but will require little or no adjustment in the fingers or crescents. We check with the operator and find that he has not touched a finger for several weeks even though he has been running various and dissimilar types of corrugating medium. We learn further that the average serviceable life of the fingers or crescents, even on a three-shift operation, runs better than 90 days.

The adjustment between the fountain-applicator roll, on the one hand, and the metering-doctor roll, on the other hand, is made entirely from the operating side of the machine. It can be made very easily, and here again a calibrated disk shows exactly what the setting is. Thus the operator can quickly compensate for changes in the viscosity of the adhesive or for the variations in the absorptive characteristics of different corrugating media. There is ready means to change the direction of rotation of the doctor or metering roll, this to obtain the most favorable conditions depending upon whether starch or silicate is being used.

Although casual inspection of the machine does not disclose this, we know that the corrugating rolls have been machined on special precision roll cutting machines developed for this particular purpose and have subsequently undergone a

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grinding, lapping, polishing operation. They are accurate to within tolerances that would have seemed absolutely fantastic not long ago. The uniformity of the flutes in the single-face board being made testifies to a proper tooth contour, one that has been developed with a clear understanding that corrugating is not a folding tucking operation, but rather a forming molding operation in which there are incidentally some of the characteristics of the forming, molding, and drawing factors which we encounter, for instance, in the manufacture of paper caps in the paper can industry. Long experience has developed the proper relationship as between top and bottom pressure on the one hand, and side pressure on the other hand, as the two fluted rolls engage and form the corrugating medium.

Adjacent to the single facer we note steam pressure gages indicating a steam pressure at pretty close to 200 pounds. We note also that these gages indicate the pressure drop or pressure differential between the input and return manifolds of the machine, a helpful and important feature in a patented steam and drainage system developed solely for the purpose of obtaining maximum temperature conditions in corrugating units.

Underneath the overhead bridge, adjacent to the single facer, we note a pair of intermeshing grooved rolls, and a pan or container for adhesive. This is a laminating device by means of which two corrugating media can be welded together as they run through the corrugating rolls thus building up a flat crush characteristic heretofore unobtainable. Although only relatively limited quantities of double-face board have been produced by this method it has already opened up markets not heretofore available to corrugated board. We cannot help but feel that these markets will see further and possibly rather considerable expansion, especially when corrugating materials again become more abundant. This development and the possibility of new and somewhat different corrugating media which probably can be run advantageously only with corrugating rolls capable of maintaining higher temperatures than are now possible with steam, even at 200 pounds pressure, indicate the need for a further study at this point.

Now to the double facer or combiner: first, we note that the glue applicator unit, or glue machine, has been redesigned to incorporate the same adhesive applicator mechanism which we noted earlier in the single facer. We note several refinements, for instance, quick and ready means to vary the surface speed of the applicator roll, and the use of thrustors to automatically raise the table and the single-face web taking them out of engagement with the glue applicator roll as soon as the machine stops. These thrustors also automatically bring the table and single-face web back down into running position, thus making it unnecessary for the double-facer attendant to remain close to this station. This makes him more readily available to help make running splices at the single facer, to relieve a single-face operator, etc.

The double facer itself comprises 44 feet of heating surface followed by 44 feet of cooling and pulling surface. We notice the heavy construction, the use of antifriction bearings throughout, the new and improved belt tighteners, quick and ready means to increase or decrease the top ballast, or in other words, the number of top idlers in use. Here again we note steam gages and a readily accessible pilot valve, all a part of the steam system mentioned earlier, by means of which the temperature in the double facer can be varied to suit the speed and the materials being run, thus contributing greatly toward minimizing warpage.

Immediately behind the double facer is a single revolution shear to sever the web when making slitting and scoring changes, this replacing the older, more cumbersome hand shear.

Next follows the slitting and scoring attachment which is of course triplex and equipped with a motor to quickly and easily bring new setups into line. The scoring elements are heat treated so that they will retain their contour for a long period of time.

The cutoff is of course a high-speed duplex rotary cutoff which even at 500 feet is obviously running very effortlessly. We learn that these cutoffs are tested before shipment at speeds of 700 f.p.m.

Modern sheet-handling apparatus enables three men to handle the output of the machine even at 500 f.p.m. without undue physical effort. This comprises a right-angle sheet delivery for the top station of the cutoff, and a fairly recently developed straight in-line "batch" delivery for the lower station. Here, sheets regardless of size are accumulated in accurately counted bundles or stacks and delivered to the take-off table at low velocity. We note that this delivery is particularly suited to very small sheets which may have to be run three and four out, as well as to extremely long sheets such as are now being called for in the packaging of television sets, various furniture items, etc.

This corrugating unit, as is true of most of those we are currently building, includes what is known as the continuous running double facer feature, or, as some people identify it, the automatic order changer. This permits of making both slitting and scoring and cut-off length changes without shutting down the double facer. It obviously results in considerable savings both in operating time and in waste. It functions as follows: The attendant at this point sets up that pair of shafts in the slitting and scoring attachment which is to come into use on the next order. He then presets the cutoffs. About 15 or 20 seconds before he wants to make the change he sounds a warning signal so that the single-face operator and in fact the whole crew will know that a change is about to be made. He then presses a button which brings the automatic control apparatus into action. This performs the following steps. First it slows the double facer and related elements such as the slitting and scoring attachment and the cutoff down to a speed of about 200 f.p.m. Then the single revolution shear above referred to severs the web immediately behind the double facer. The double facer then slows down to 30 f.p.m. while the slitting and scoring attachment and cutoff continue at 200 feet. The outgoing tail clears the machine therefore at 200 f.p.m. and this provides an opportunity for the slitting and scoring attachment to revolve automatically into line before the oncoming web reaches it and similarly allows the cutoffs to reset themselves before the oncoming web reaches them. When this has been done the double facer automatically resumes the speed of 200 f.p.m. The total time required for this entire cycle is less than 60 seconds.

With the high frequency of slitting and scoring changes in most plants this is a valuable factor, particularly in terms of reducing waste.

This has been but a brief description. Needless to say we will welcome an opportunity to discuss more specifically any points on which you may wish to raise questions, either here in this meeting or subsequently.

Now as to the future. There is certainly nothing more tempting and nothing more dangerous than to look into that good old crystal ball. We are constantly searching for new things and scanning the horizon for anything that may conceivably bring about some more important changes, but frankly do not see anything very revolutionary or drastic. Indications are that we more likely will see a continuation of the orderly evolution we have been experiencing. So far as the things that we are more immediately working on here are a few that might be of some interest.

First as regards the single facer. We have felt for some time that the adjustments by means of which we control the pressure between the two corrugating rolls are rather crude. Even the new, heavy duty, high-speed machine we have just described utilizes the old-fashioned handwheels, screws, and heavy duty springs. These comprise the time-honored and on the whole the rather effective apparatus with which we

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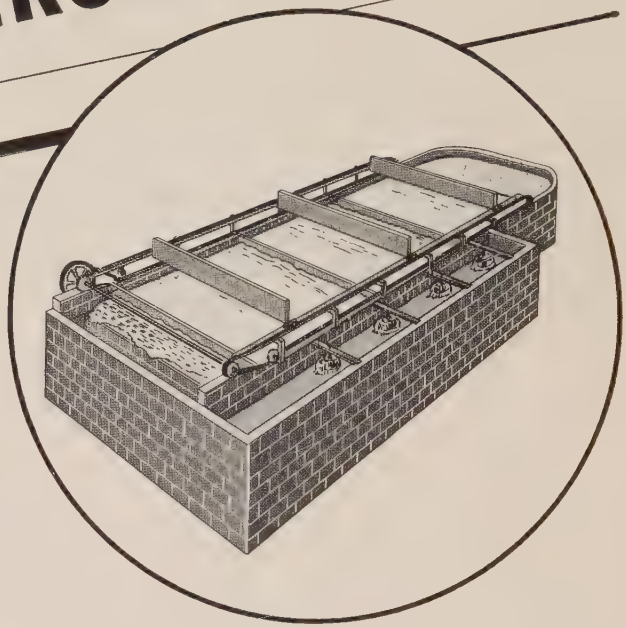

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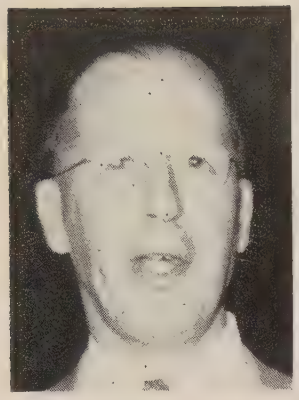
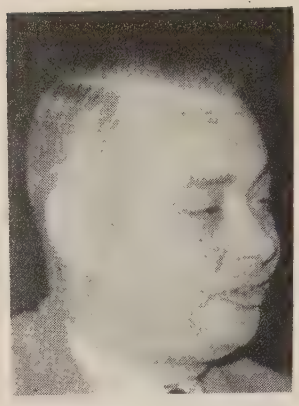


A. E. Montgomery, J. O. Ross Engineering Corp.



G. E. Field, B. F. Goodrich Chemical Co.

are all familiar. We have felt, however, that there is a definite need for a more convenient adjustment which can be made by the operator without physical effort and entirely from the operating side of the machine, and a reasonably accurate indicator of some kind which would show the amount of pressure being applied. I am happy to say that a pilot installation of hydraulic apparatus which we put on a production machine about 2 months ago looks extremely promising. In fact it looks so promising that we are in the midst of equipping three more machines.

Now another point on the single facer. We have observed that when running laminated materials we need more heat. We suspect that other special corrugating materials could be successfully run if we could maintain very much higher surface temperatures and also feel that many of the corrugating materials now in regular use would benefit by still higher temperatures. To increase steam pressure beyond 200 pounds does not appear to be promising because we get into only very small increases in temperature even with appreciably higher pressures which of course involve many difficulties even where high-pressure steam might be available. Our thinking here is that liquid heat carriers may provide a sound solution. We have been working in collaboration with several of our customers on this problem and have carefully investigated the relative merits of such liquid heat carriers as the special oils more recently developed, and such chemicals as for instance Arachlor. Pilot installations have been made which indicate to us a definite need for some design changes in the single facer, principally larger openings in the corrugating and pressure rolls, means to introduce the heat carrier at one end and take it out at the other, means to maintain a high rate of flow immediately adjacent to the inside wall of the rolls, etc. The first installation in which we will have corrugating and pressure rolls which provide for these features, will probably be put into operation the latter part of this year.

Another point: we are constantly studying various possibilities of increasing the serviceable life of corrugating rolls. There is not much we can say at this point but we thought you might be interested to know that it is something to which we are giving considerable thought.

We are constantly studying the problem of how to eliminate warpage in the double facer.

We have a number of other projects under contemplation but none of these is far enough along to warrant discussion here.

In the main, the machine of the future will reflect our constant effort to help solve the problems which you men in the operating and technical end of the container industry call to our attention. The close cooperation which we have enjoyed has not only been the source of much real pleasure and satisfaction, but has been one of the most important factors in the progress that has been made so far.

Q.: Does chrome plating offer any possibility as a means of increasing corrugating roll life? What other considerations are under consideration for this purpose?

A.: Chrome-plated rolls will give 50 to 100% longer roll life, but must be carefully handled by the operator. Chrome being brittle, rolls should not be run dry without paper between them. Nitrided rolls are scarce due to lack of steel. Wear is also affected by loading pressure, 80% of the machines are running with excessive loading.

Q.: Has any improvement been made on belt joining to reduce damage to board?

A.: Nothing worth talking about.

Q.: What are the corrugator roll loading requirements of various corrugating mediums?

A.: Kraft or semichemical needs two to three times the amount of pressure needed by the bogus sheet.

Q.: Why does the rotation of the doctor roll have to be reversed when changing from silicate to starch adhesive?

A.: With silicate it is difficult to have a scraper keep the doctor roll clean since the scraper will become scored and rings will develop with loss of film thickness control.

Q.: What is the effect of superheated steam on the corrugator?

A.: Superheated steam (200° of superheat) caused no trouble on the double backer but did on the single facer. Corrugating rolls call for very high heat transfer rates. Superheated steam being a gas does not liberate a large amount of heat until it drops to the saturation point and condenses or, saying it another way, the greatest and fastest release of heat is from saturated steam after the superheat has been dissipated. With superheated steam rolls run too cold. An instrument is being developed to measure the temperature of a moving corrugator roll since there are no reliable surface pyrometers available at the present time.

Q.: Why do we need a "cooling" section and what does it do for quality?

A.: The so-called "cooling" section is a tractor section without which cutoff would be impossible. The section tempers by completing the bond and equalizes moisture and temperature so that a sheet free from warp and tensions is delivered.

Q.: What is the function of live steam on corrugating medium?

A.: It aids in plasticizing the sheet.

Q.: Wouldn't it be better to build the moisture into the sheet?

A.: It would lead to soft rolls, shrinkage, etc.

Q.: Can the showers get enough moisture into the sheet at high speed?

A.: We have had to move the shower farther away from the corrugating rolls for high-speed operation. The shower also heats the sheet so that a combination of heat and moisture is necessary.

Q.: Is caliper loss a result of high speed?

A.: If rolls are doing a good molding job, caliper loss is due to medium shrinkage. If the operation is slow, board is dried and less shrinkage results.

Q.: Could there be slippage between rolls?

A.: If rolls are in good shape there is little chance for slippage.

Heating and Drying Problems

A. E. Montgomery, Vice-President of the J. O. Ross Engineering Corp. discussed "Theoretical Problems of Heating and Drying" by treating the corrugator operation as a heat transfer problem.

"Drying on a corrugator combiner is not a simple requirement of water evaporation and removal as in the usual drying operations. The prime consideration is the application of heat in such a way as will develop the fullest value of the adhesive and will produce a board which will remain flat. As for any other drying problem, however, thinking may be clarified by considering the problem as one of heat transfer, for the greater the rate of heat transfer from the steam inside the corrugating rolls or the drying plates into the board the greater the production which can be secured.

"The basic formula for heat transfer is usually written: $Q = U \times A \times \Delta T$, where Q is the quantity of heat expressed in B.t.u. per hour, U is the coefficient of over-all heat conductance expressed in B.t.u. per hour per square foot per degree F. difference in temperature, A is the heat transfer area in square feet, and ΔT is the difference in temperature in degrees F. between the steam on the inside and the material being heated on the outside. Any means which will increase any one

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The waste-treatment plant cost *even less* than the supposedly-cheap makeshift equipment that had failed, and it provided an effluent completely acceptable for re-use in the mill.

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- **A large amount of raw stock was recovered**
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The manufacturer estimates the new system will have paid for itself within three years!

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of the factors on the right side of this equation will increase Q and thereby allow for increased production.

"The over-all heat conductance is affected by the following factors:

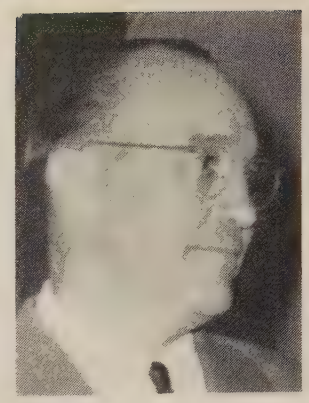
1. Dropwise versus film type condensation.
2. Vapor velocity.
3. Complete removal of the condensate from the inside of the heating surface.
4. Presence of noncondensable gases. Even small percentages built up by inadequate venting or steam circulation can greatly reduce the heat conduction.
5. Superheat in the steam. Superheated steam is no better than saturated steam at the same pressure, and may be worse.
6. Scale or dirt deposit on the steam side.
7. Thickness of drier plates or wall of corrugating roll.
8. Material of metal wall. From a heat transfer standpoint, for example, copper has about eight times as great conductivity as iron or steel.
9. Outer surface of metal. The intimacy of contact between metal and paper is of dominant importance. Heater plates should be perfectly smooth and flat and level, to make complete and uniform contact with the paper.
10. Surface of paper. A smooth liner would receive heat more rapidly than one with rough or irregular surface.
11. Pressure exerted by rolls on belts, and hence the pressure of the paper on the plates.

"The factor A is simply the amount of heat transfer surface, and can only be increased by lengthening the drying section. The factor ΔT can be increased either by raising the steam pressure or by lowering the drying temperature as by use of air. If the removal of water were the only consideration the latter would have interesting possibilities, but it is recognized that the desired properties of the board may require use of elevated temperature over some certain time period. Too little is known about this, and a fertile field for some research is apparent."

Q.: Is it practical to displace the air in the flutes of combined board before the board leaves the cooling section?
A.: The blowing of hot air through the flutes to prevent condensation has never worked out practically.
Q.: Isn't drying in effect just evaporating the moisture and if so would good circulation of dry hot air be desirable?
A.: Nomenclature in the industry is misleading. Very little drying is accomplished in the drying section. It should be called the "adhesive setting" section.

Lake Erie Section Meeting

At a dinner held Friday evening, Chairman Burnett of the Lake Erie Section introduced R. G. Macdonald, Secretary-Treasurer of TAPPI, who discussed the historical background leading to the formation and development of National TAPPI and the sectional groups and concluded by presenting Chairman Burnett with a charter and gavel symbolizing the official acceptance of the Lake Erie group as a local section of TAPPI. Richard P. Price, TAPPI Executive Committee Member and Vice-President of the Hammermill Paper Co., welcomed the Lake Erie Section and stated that everyone had been impressed with the steady growth of the group to its ultimate goal of a local section status. A short business meeting was held at which time the new constitution previously circulated to the members was voted on as was the new slate of officers for the year 1951–52. The new slate included William Hasselo, Container Corporation of America, as Chairman; Joe Thompson, Minerva Wax Paper, 1st Vice-Chairman; R. L. Lewis, Ohio Boxboard, 2nd Vice-Chairman; William Schoenberg, Lord and Schoenberg, Treasurer; and L. E. Rolig, Ohio Boxboard Co., Secretary.



R. P. Price, Hammermill Paper Co.; TAPPI Executive Committee Section Representative

William Hasselo, Container Corp. of America; Chairman, Lake Erie Section

Chairman Burnett introduced representatives from the Ohio, Lake States, Pacific, Chicago, and New England Sections.

Chairman Burnett turned the meeting over to the new Chairman, Bill Hasselo, who introduced Pete Spring, retiring 2nd Vice-Chairman. Pete presented Bill Schoenberg with a testimonial document commending Bill for his efforts on behalf of the Lake Erie Section during its infancy. Pete also presented retiring Chairman Burnett with a cocktail set in appreciation of his work in guiding the Lake Erie group over the road to success as one of the local sections of TAPPI.

George E. Field, Technical Service Manager of the Plastics Division of the B. F. Goodrich Chemical Co., gave an inspiring talk on the subject "Development Requires Cooperation." Mr. Field drew on his experience in the development of synthetic rubber to outline the need for more cooperation between technical and operating personnel in industry today. He stated that many progressive steps have been blocked many times by attitudes and misconceptions between technical and operating people. Many times this is a case of failure to use salesmanship and misunderstanding of the other fellows problems, which properly treated results in smoother relationships, cooperation, and progress.

R. L. Lewis, *Publicity Chairman*

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View of Potlatch Forest's new machine room with ROSS Insulated Panel Hood over machine and ROSS Heating and Ventilating apparatus above. Insert shows 6 exhaust fan outlets from the hood. Other ROSS equipment includes heating and ventilating systems for Beater Room, Finishing Room and Basement as well as Calender Cooling.

"Paper Over" was announced by Potlatch Forest's, Inc. in slightly more than 11 months from the day ground was broken for their great new mill at Lewiston, Idaho. On that day it became the first mill to make and use virgin wood pulp in an entire area extending over 14 states. Another epochal event in which the dependable ROSS Air Systems played their important part in helping to insure maximum operating efficiency throughout this notable new mill.

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Sulphur

A CHEMICAL AND ENGINEERING NEWS STAFF REPORT

SELDOM does a week go by without sulphur touching off a blaze of newspaper headlines. Without doubt, sulphur—the subject of earnest deliberations, endless conferences, and bold new programs—is the chemical industry's supply problem number one. The scarcity reaches out into every sector of American industry. Its effects are global. As one raw materials expert commented tersely: "Sulphur is the hottest subject on the calendar."

The U. S. chemical industry, which for years has been burning sulphur at a tremendous rate, has taken it entirely for granted that sulphur would come roaring out of Texas and Louisiana forever. Now, the cruel awakening.

Predictions are that U. S. native sulphur deposits will be exhausted within 25 years. Early this month, the sulphur committee of the International Materials Conference estimated the 1951 world sulphur shortage to be at least 1 million tons, or about 20% of U. S. production. Because there is little immediate prospect of any significant increase in the U. S. sulphur supply most consumers will have to face the fact that, for the time being, about all they can do is tighten their belts and hope for the best.

Canadian pulp and paper manufacturers, consuming at present about 80% of Canada's sulphur imports (almost all of which come from the United States), have been saying that unless the industry gets more sulphur, the production of newsprint is certain to nosedive. In mid-April, James M. Quinn, president of the California Fertilizer Association, wired officials of the National Production Authority that, as a result of the diversion of sulphuric acid to the nation's oil companies, the amount of acid now available for producing superphosphate and ammonium sulphate is "critically short of amount needed to meet minimum California and Arizona demands. Added demand caused by shortage of agricultural fertilizer materials results in desperately serious situation for growers." At Houston, Tex., the sulphuric acid shortage forced Phillips Chemical Co. to cut its ammonium sulphate production by 35%. Said Jefferson D. Stewart, executive vice president of Federal Chemical Co.: "Because of the superphosphate shortage [caused by the scarcity of sulphuric acid], we have laid off night crews altogether. At times, some of our plants have been completely idle."

Last fall, Texas Gulf Sulphur reduced its domestic shipments to 80% of its customers' maximum contract requirements. On Jan. 1, 1951, Freeport Sulphur began allocating its sulphur on the basis of 85% of the 12-month base period ending Sept. 30, 1950. The cuts announced by both Texas Gulf and Freeport—which together turn out approximately 90% of the nation's Frasch sulphur—have been in effect ever since. As part of the chain reaction, major chemical manufacturers began telling their customers to expect 15 to 20% less sulphuric acid in 1951.

There are any number of ways to gage the sulphur shortage. One is by price; another is by the above-ground stocks of elemental sulphur. Although today the standard price of U. S. sulphur is $21 to $22 a ton small quantities are being resold in this country at $60 to $90 a ton. Some companies have been willing to pay as much as $120 a ton—or over five times the standard contract price. Obviously, such fancy prices are being paid because some hard-up manufacturers simply cannot get sulphur by any other means at any lower price.

At the close of 1950, stocks of native sulphur at U. S. mines amounted to 2.4 million long tons, as compared with 3.5 million long tons at the end of 1945 and 4.0 million long tons at the end of 1939. In years past, above-ground reserves have represented at least an 18-month sulphur usage. Now the sulphur pile is equivalent to not more than a 6-month supply—generally regarded as the "irreducible minimum." Even last year, when the perils of a steadily dwindling sulphur reserve became all too evident, the industry sold 445,000 more tons of native sulphur than it produced.

PRODUCTION AND USE

In 1950, the industry's peak year, U. S. producers turned out 5,192,184 long tons of native sulphur. This constituted a 148% increase over 1939 and a 38% increase over the top output of World War II. In all likelihood, the upsurging American chemical industry 10 years hence will be consuming sulphur at more than twice its present rate—if the sulphur industry can satisfy the demand.

Last year, about three-quarters of U. S. sulphur went into the production of sulphuric acid. The tremendous increase in sulphur usage during the past few years has gone hand in hand with the phenomenal rise in the use of sulphuric acid not only in the manufacture of fertilizers (which in 1950 took 44% of U. S. sulphuric acid) but in the production of chemicals (16%) and petroleum products (12%).

The greatest single reason for the speed-up in sulphur production has been fertilizers. For example, although in 1939 only 1.23 million short tons of 100% sulphuric acid went into the making of superphosphate fertilizer, in 1950 superphosphate production required a full 3.95 million short tons—an increased acid consumption of over 220%. This greatly extended usage has resulted not only from the effective educational programs that have convinced farmers of the merits of fertilizers but also from the very fact that farmers in recent years, as never before, have had the cash-in-hand to purchase fertilizers in unprecedented quantities.

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The manufacture of titanium dioxide, nitroglycerine, DDT, phenol, rayon, and synthetic detergents consumes sizable amounts of sulphuric acid. So does the pickling of metals and the production of zinc, aluminum, magnesium, and copper. The petroleum industry counts on sulphuric acid in the production of alkylate, cracking catalysts, drilling muds, and lubricating oil additives.

Sulphite pulp manufacturers call for immense quantities of sulphur dioxide. Elemental sulphur goes into the making of rubber, medicinals, carbon disulphide, sulphur dyes, and pesticides. These, of course, are but a few of the countless outlets for the nation's sulphur. A complete enumeration of sulphur's direct and indirect applications would require a recital of every major technological advance of the industrial age.

Before the lush days of the Gulf Coast salt domes, U. S. sulphur came principally from pyritic ores. Pyrites (the all-inclusive name for metal sulphide minerals containing 25 to 50% sulphur) were roasted to form sulphur dioxide, which, in turn, was converted to sulphuric acid. Pyrites, although merely a fringe source of sulphur in this country today, are still the chief sulphur source for most of the rest of the world.

In 1867, prospectors searching for new petroleum reserves accidentally stumbled upon sulphur near Lake Charles, La. Beneath the marsh, muck, quicksand, and rock, they found sulphur of extraordinary purity. The big problem was getting the sulphur out of the ground. Several companies tackled the job headlong by using standard mining techniques. Time and again, their efforts ended in failure. Then Herman Frasch came up with the idea that sulphur might be mined successfully by melting the element underground with hot water. Although he filed a patent application for the process as far back as 1890, Frasch had to wait over 15 years—a period marked by repeated setbacks—before he could pronounce the venture a success.

The establishment of the Union Sulphur Co. by Frasch in 1896 was followed by the formation of the Freeport Sulphur Co. in 1912, the Texas Gulf Sulphur Co. in 1918, the Duval Sulphur and Potash Co. in 1926, and finally the Jefferson Lake Sulphur Co. in 1932. Freeport, Texas Gulf, Duval, and Jefferson Lake—owning plants in either Texas or Louisiana are today the only U. S. companies producing native sulphur by the Frasch process.

At the turn of the century, the fledgling American sulphur industry produced somewhat more than 3000 tons of brimstone a year. Today, the industry is turning out approximately five times that amount in a single day. In 1900, with the aid of imports, mainly from Sicily, the U. S. consumed about 500,000 tons of sulphur, including sulphur from pyrites. Translated into contemporary terms, this usage is equivalent to about a 6-week consumption of sulphur in all forms.

Even by 1910, only about 5% of all U. S. sulphuric acid came from brimstone; the remainder was based on pyrites. Actually, brimstone never made much of a dent in the U. S. chemical industry until World War I, when the importation of pyrites, chiefly from Spain, was abruptly curtailed. Under the harassment of submarine warfare, the United States was forced to turn increasingly to Gulf Coast sulphur. That trend continued.

GULF COAST SULPHUR

The great bulk of elemental sulphur now produced in the United States first sees the light of day along the Gulf Coast. Out of a total of over 200 salt domes discovered in that area, only 12 have every attained commercial status. The others have either been barren or of little potential value. Of the 12 workable domes, seven are in operation today; the remaining five have been exhausted.

Had it not been for the exceptional merit of the Frasch process, the United States might today have had a genuinely diversified sulphur industry. Instead, the industry placed practically all its chips on Gulf Coast sulphur. Other sulphur sources were largely neglected. However, now that it has become more than obvious that Gulf Coast production cannot keep pace with demand, the chemical industry is being forced to look elsewhere.

The U. S. has six basic alternatives: pyrites, hydrogen sulphide (from natural and refinery gases), smelter gases, calcium sulphate, coal, and low-grade sulphur deposits. Ironically, the most costly sources of sulphur (as far as recovery is concerned) are not only the most plentiful but also the most widely distributed; they are calcium sulphate and coal. In 1950, the U. S. obtained 9.0% of its sulphur from pyrites, 2.4% from hydrogen sulfide, and 4.0% from smelter gases. The remaining 84.6% was Gulf Coast sulphur.

Because of their high cost, alternatives for Frasch sulphur are at present very much in the background. However, as U. S. reserves steadily decline, the price of elemental sulphur will inevitably rise. Simultaneously, the production of sulphur from what currently are regarded as marginal sources will become ever more attractive. As William L. Swager of Battelle Memorial Institute observed: "At present, it appears that any increase in the supply of sulphur will have to come from by-product sources. . . . There is plenty of sulphur available, but not at the price that is currently being paid for brimstone. The economic driving forces indicated by the estimated demand for sulphur in 1960 will gradually bring to the market increasing quantities of by-product sulphur at increasing process. . . . There appears to be no long-term sulphur shortage nor any revolution in the industry that will have severe repercussions. It will be a gradual struggle between the suppliers and the consumers in the market place."

SULPHUR FROM PYRITES

Pyrites are the chemical industry's most compelling alternative to Gulf Coast sulphur. However, at brimstone's present price, the production of sulphur from pyrites is a comparatively costly proposition. In fact, when a manufacturer decides to build a pyrites-burning sulphuric acid plant, he must resign himself to paying more than twice what it would cost him to build a comparable sulphur-burning installation. However, calculations are that the production of sulphur from pyrites will successfully compete with Frasch sulphur when the price of brimstone at the mine rises to at least $30 a ton.

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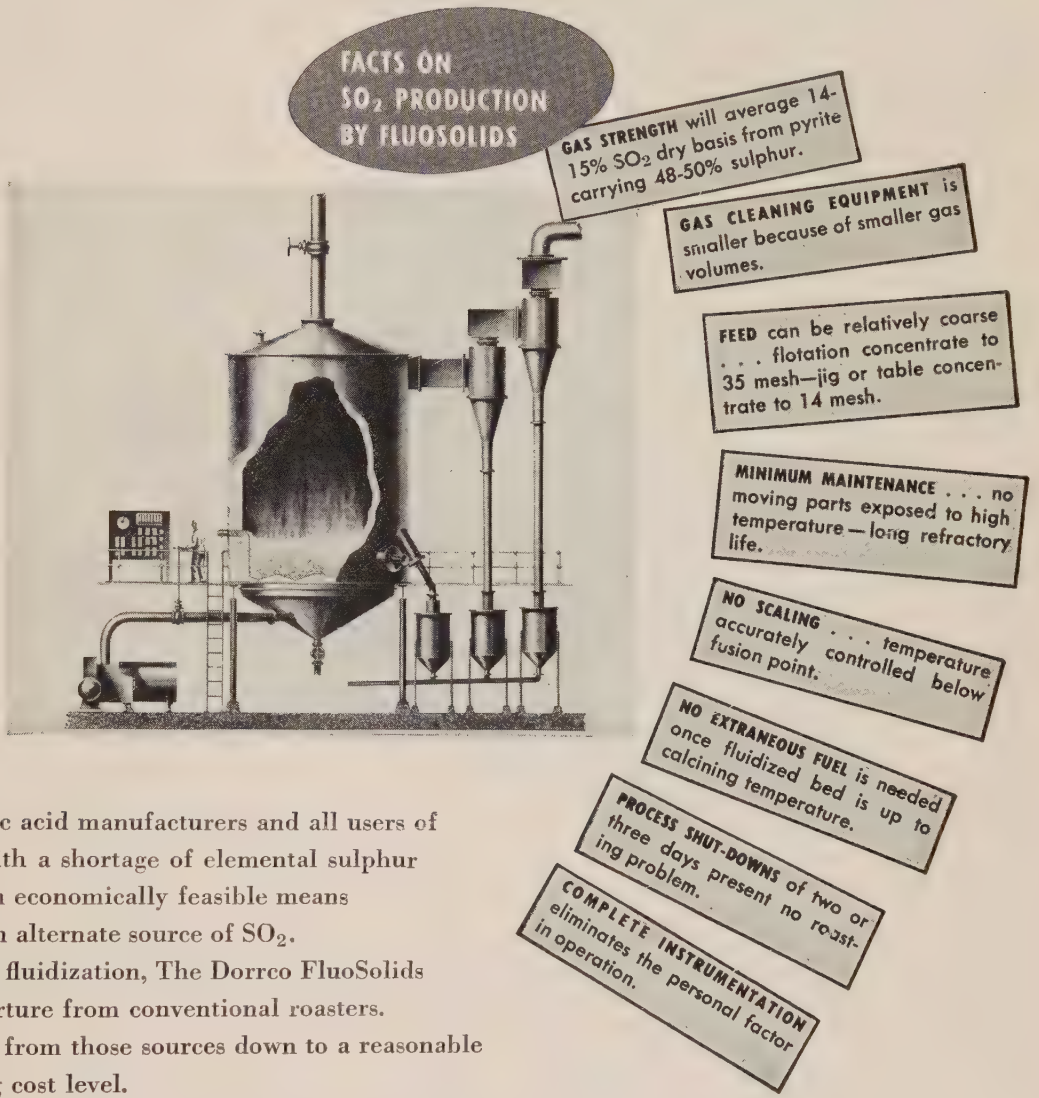
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Within recent years, the use of pyrites as a sulphur source has been limited largely to those plants which, because of their ideal location, are favored by low shipping costs and special market and raw material advantages. The major share of U. S. pyrites production centers around Tennessee, although suitable ores also occur in eight other states. Estimated U. S. sulphur reserves in the form of pyrites: 76 million tons.

Flash roasting is by far the most widely used method of recovering sulphur dioxide from pyrites. Recently, the Dorr Co. adapted its FluoSolids system (originally developed for the calcining of gold ores) to the recovery of sulphur dioxide from pyrites. In the FluoSolids system, 35 to 200-mesh sulphide particles are partially suspended in an upward-moving stream of air. The fluidization of the solids ensures the complete combustion of the particles of sulphur dioxide, which may then be converted to sulphuric acid.

SULPHUR FROM NATURAL AND REFINERY GASES

The recovery of sulphur from the nation's oil fields, gas fields, and petroleum refineries can be justified on several grounds: a valuable resource becomes a source of additional income; the sulphuric acid subsequently produced stimulates the growth of other industries in the same area; and besides, the operator is assured that his effluent gases won't play havoc with the surrounding countryside. Oftentimes, the removal of foul-smelling hydrogen sulphide from natural gas isn't just a nice, possibly lucrative, gesture; it's a downright necessity. Not only is hydrogen sulphide highly poisonous (at least five times as toxic as carbon monoxide) but it is also exceedingly corrosive and may lead to disastrous product contamination and costly catalyst poisoning. These factors, plus the urgency of the sulphur shortage, have spurred many companies into taking long, discerning looks at their sulphurous plant gases.

The most common method of obtaining sulphur from natural or refinery gases starts with the recovery of hydrogen sulphide by the Girbotol process. Hydrogen sulphide is absorbed by an ethanolamine solution and then stripped from the absorbent by heating. Next, the isolated hydrogen sulphide is partially burned to sulphur dioxide. In a special catalyst chamber, the gases are converted to elemental sulphur and water.

Because not very many natural gas sources contain sufficient concentrations of hydrogen sulphide, the usefulness of this technique has its distinct limitations. In the West, however, the recovery of hydrogen sulphide from sour natural gas is particularly appealing, not only because of the high sulphur content of the gas but because there are enough superphosphate plants around to provide a ready and sustained market for sulphuric acid. At present, Texas Gulf is recovering 100,000 tons of sulphur a year from sour natural gas at Worland, Wyo. At McKamie and Macedonia, Ark., Mathieson Chemical is salvaging 53,000 tons of sulphur a year from Arkansas sour gas. Hancock Chemical recovers sulphur at a rate of 25,000 tons a year from oil refinery gases in the Los Angeles area, while Freeport Sulphur reclaims 4500 tons of sulphur a year from the refinery gases that pass through its plant near Westville, N. J.

Said W. C. Huffman of the Petroleum Administration for Defense: "Refiners have periodically reviewed the economics of sulphur recovery from their operations . . . . In the past, it has ordinarily not been economic, what with the low price of sulphur and its ready availability. That situation has shifted, and a number of refiners are finding that it is not only necessary to institute means of recovering sulphur from their operations in order to have acid at all, but it is economically attractive under the present situation. . . . The difficulty is that the equipment required for the process will take time to construct and put into operations. Although there may be spot situations where something can be done quickly to expand existing recovery, any major contribution from petroleum operation seems to be some distance off."

SULPHUR FROM SMELTER GASES

Each year, tremendous quantities of sulphur dioxide are evolved in the smelting of nonferrous sulphide ores. Annually, in the United States and Canada, a total of about 1 million long tons of sulphur are potentially recoverable from the smelting of zinc ores, 750,000 long tons from nickel ores, and 3.5 million long tons from copper refineries. What with the rising price of sulphur and the crippling scarcity, the need for the recovery of sulphur from such sources has taken on a new dimension. In 1949, the equivalent of only about 296,000 long tons of sulphur was obtained as sulphuric acid from smelters in the United States and Canada.

SULPHUR FROM CALCIUM SULPHATE

Although sulphur is widely distributed in nature as calcium sulphate, the cost of recovering sulphur from this source is ordinarily prohibitive. Currently, TVA is exploring the production of sulphuric acid from calcium sulphate, either in the form of natural gypsum or as a chemical by-product, particularly from the "wet process" manufacture of phosphoric acid. At Merseyside, the British are building an installation to produce 150,000 tons of sulphuric acid a year from anhydrous calcium sulphate. The new installation, costing between $9.8 and $11.2 million, will be patterned after the 100,000-ton sulphuric-from-anhydrite unit that ICI built at Billingham in the early 1930's.

SULPHUR FROM COAL

The hydrogen sulphide now being evolved in U. S. coal carbonization plants could add about 200,000 tons annually to the nation's sulphur supply. In turn, this sulphur could be converted to sulphuric acid for use in transforming by-product ammonia into ammonium sulphate fertilizer. In fact, the sulphuric acid obtainable in this fashion could meet about 60% of the coke industry's acid requirements. According to George P. Wilson of the Solid Fuels Administration, such hydrogen sulphide recovery is economical in coke plants which handle at least 4000 tons of coal a day. This includes the majority of U. S. coke plants.

Locked up in the world's coal deposits are enormous amounts of sulphur in the form of pyrites. At present, however, only a very limited amount of pyrites is being recovered from coal. Because the pyrites content of

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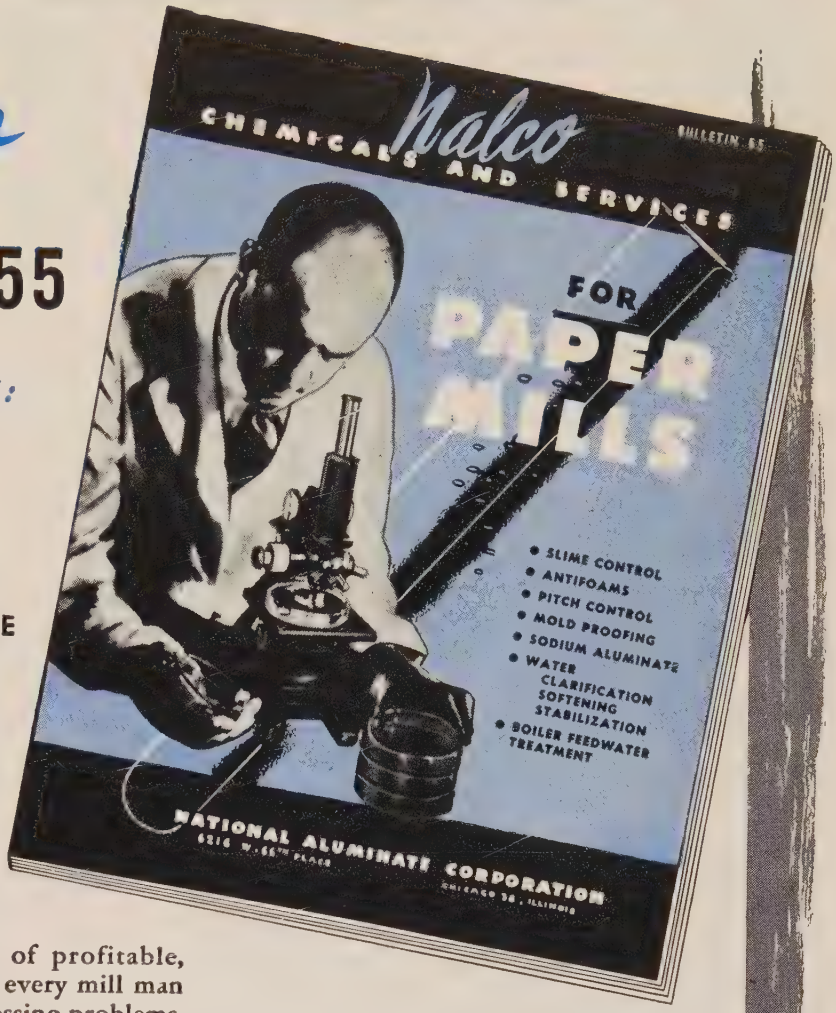

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coal is seldom more than 3%, the recovery of sulphur from "coal brasses" is definitely on the costly side.

LOW-GRADE SULPHUR DEPOSITS

In 1949, approximately 5700 long tons of sulphur ore were produced by ordinary mining techniques in California, Colorado, Nevada, and Wyoming. Because this material normally fails to reach the purity of Frasch sulphur, it is principally used in correcting the alkalinity of soils. Chemical Construction Co. points out that such relatively low-grade ores might serve as a valuable raw material for the production of high-grade sulphur. Moreover, Chemico's engineers have devised a process to do the job (*C&EN*, Feb. 12, 1951, page 560). Their process involves the pulverization of the ore to less than 28 mesh. The product is then heated above sulphur's melting point. Once the molten mass is isolated from the gangue, the impure brimstone is chilled, separated, remelted, filtered, and finally collected as 99.5% sulphur.

Substantial quantities of sulphur can be saved each year by the simple expedient of sending less sulphuric acid to the ditch. Some branches of the chemical industry have for years been notorious wasters of sulphuric acid. Although in the past, many such companies would have pooh-poohed the idea of ever recovering waste acids, they are finding such recovery increasingly easy to justify in the present emergency.

Sizable quantities of sulphuric acid may be retrieved in scores of plants. Sulphuric acid can be salvaged from spin bath solutions in rayon plants. Petroleum refineries can tighten up on their acid recoveries. Steel mills can do a far better job of reclaiming their spent pickle liquors. Said C. F. Prutton, vice-president of Mathieson Chemical Corp.: "Greater emphasis should be placed upon the use of recovered sulphuric acid and waste sulphuric acid in the manufacture of phosphate-containing fertilizers. In peacetime or normal times, there is a tremendous demand by agricultural people for nice, light-colored superphosphate made with nice, clear acid, made from virgin sulphur. In our plants, we have adopted a process which uses recovered acid for the manufacture of phosphate fertilizer. We have seen no reason why waste acid cannot be used to advantage. As a matter of fact, in some parts of the country, we find that the dark-colored superphosphate is preferred over the light-colored."

ECONOMIZING ON SULPHUR

Those who are most vigorously urging that the chemical industry recover maximum amounts of waste sulphuric acid are, at the same time, championing the cause of using less sulphuric acid in the first place. Admittedly, many of the proposed techniques designed to reduce sulphur consumption are either untried, unproved, or uneconomical. However, some have merit.

Various Department of Agriculture representatives have recommended that nitric acid be substituted, at least in part, for the sulphuric acid currently being employed in the conversion of phosphate rock to superphosphate fertilizer. Processes along these lines have for years been commercially used in Western Europe. The French, for example, have developed a nitric-sulphuric process for fertilizer manufacture that is said to reduce sulphuric acid consumption by one half. The main drawback in working with nitric acid is the fact that the product usually picks up a substantial amount of moisture and forms massive lumps. Recently, ICI researchers, in developing a method of producing phosphate fertilizer solely by the use of nitric acid, found a way of getting around the caking problem.

TVA has come up with a method of its own for obtaining superphosphate fertilizer without the use of sulphuric acid. An electric furnace does the job—by yielding elemental phosphorus, which is directly convertible to phosphoric acid. On the debit side, the TVA process demands appreciable quantities of electrical power, which in many parts of the country is neither overly cheap nor overly abundant.

NEWS ON THE SULPHUR FRONT

For months, the Gulf Coast sulphur lands have been buzzing with unprecedented activity. Not only is output today at top level, but so are efforts to bring in new sulphur deposits never before tapped.

Last October, Texas Gulf—which has invested over $11 million in the development of new sulphur sources during the past 3 years—began constructing a sulphur plant at Spindletop Dome, near Beaumont, Tex. Scheduled for completion late this year, the plant is expected to have an annual output of at least 250,000 tons. Recently, Jefferson Lake Sulphur put the finishing touches on its sulphur mining facilities at Starks Dome, La. Stanolind is seriously considering the development of a sulphur dome at High Island, just southeast of Galveston.

Freeport Sulphur has launched an exploratory drilling program at four new properties in Louisiana. In addition, the company intends to set up an amphibious sulphur mining plant at Bay Ste. Elaine, a swampy stretch of coastline southeast of New Orleans. Since the land overlying the area's sulphur dome is two thirds under water, Freeport will have to use special drilling equipment, special techniques. Plans include the construction of a power plant supported on a steel barge approximately two thirds of a city block long. Capacity: nearly 2 million gallons of superheated water a day.

More sulphur recovery plants are on the way. Recently Lion Oil Co. announced that it will begin salvaging 10 tons of sulphur a day from sour natural gas at its Magnolia, Ark., plant. Both Phillips Petroleum and Shamrock Oil and Gas are setting up new installations to reclaim sulphur from refinery gases. Consolidated Chemical Industries has a plant under construction at Baton Rouge for producing 25 to 30 tons of suphur a day from waste gases obtained from the nearby Esso Standard Oil refinery.

In February, Freeport Sulphur was granted an option to purchase 7700 acres of land and mineral rights from Virginia Iron, Coal, and Coke Co. in Carroll County, Va. Abounding in pyrites ore, the property will sell for about $2.5 million. In April came an announcement that Wyoming Gulf Sulphur Corp., a recently organized outfit in Dallas, plans to produce refined sulphur from low-grade deposits in Park County, Wyo., 2 miles from Cody.

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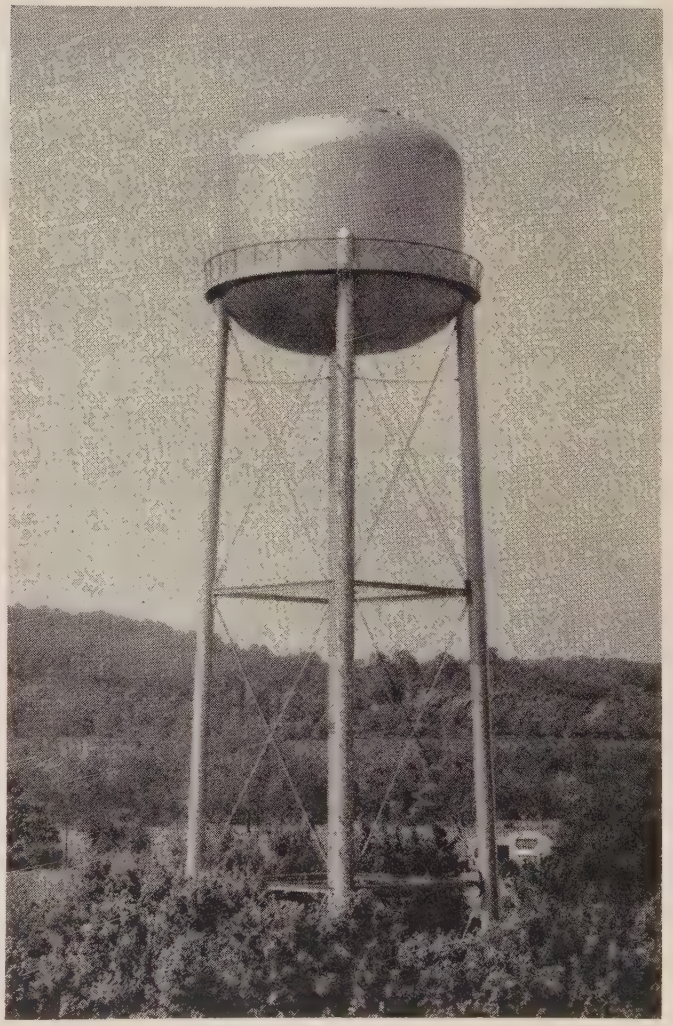

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Reports are that Noranda Mines of Canada will build a $4 million plant to obtain sulphur from pyrites. About 50 tons of elemental sulphur will be produced daily, in addition to 100 tons of sulphuric acid. Shell Oil Co. of Canada will set up a $500,000 plant at Jumping Pound, Alberta, to recover about 30 tons of elemental sulphur a day from sour natural gas. This additional supply, which will go principally to the local pulp and paper industry, will be a much-needed shot-in-the-arm for Canada's newsprint manufacturers.

In their quest for new sulphur deposits, prospectors have combed the Gulf Coast area repeatedly over the past 10 to 15 years. The results of these thorough-going explorations seem to point to but one conclusion: there is only the slimmest chance that new native sulphur deposits of any great magnitude will ever again be found in the land area along the Gulf. Hope, however, has not been abandoned. The president of Freeport Sulphur told a congressional committee: "We are throwing a lot of money out on the roulette wheel, and when we do, we always hope and pray. The mathematical chances of finding a large new deposit of sulphur are not very good, but we are spending money as if the chances were good, and we hope we will strike."

The successful underwater mining of sulphur in relatively shallow water in reasonably protected areas has already been achieved by two U. S. companies: Freeport and Jefferson Lake. However, the mining of sulphur at points miles offshore is a vastly different story. In fact, it is generally conceded that the offshore mining of sulphur is not economical by present-day standards. On the other hand, when U. S. sulphur reserves become considerably more depleted, it is quite possible that offshore operations may take on a new fascination.

Of late, Mexico has become a favorite stamping ground for sulphur prospectors. For over a year, Texas Gulf crews have been diligently poking around among the salt domes of the Isthmus of Tehuantepec, but still haven't hit pay dirt. Other companies intent upon discovering workable sulphur deposits have also sent exploratory teams south of the border. Activity in the area is certain to increase. Last month, the Export-Import Bank of Washington approved a $1,875,000 loan to the Mexican Gulf Sulphur Co., which plans to mine 200,000 tons of native sulphur a year at the 1.5-million-ton San Cristobal Dome deposits.

SULPHUR EXPORTS

For years, the rest of the world—much like American producers themselves—confidently assumed that the Gulf Coast sulphur supply was inexhaustible. There was little to upset the illusion. U. S. native sulphur has long been so abundant that the nation has been able to furnish vast quantities to all the rest of the world. Over the past quarter century, the United States—producer of over 90% of the world's native sulphur—has been shipping, on the average, about 30% of its production to foreign countries. Just as U. S. sulphur production has risen, so have U. S. sulphur exports. For example, last year's total exports of 1,440,996 long tons were more than twice the export tonnage of 1939.

As 1950 came to a close, the U. S. took the abrupt step that set off a drumfire of protests in dozens of countries throughout the world. As part of its re-armament and stockpiling program, the United States slashed its exports by approximately 30%. During 1951's first quarter, total crude sulphur exports to all countries other than Canada were limited to 200,000 long tons. The recently announced half-year quota: 480,000 long tons.

During the first quarter of 1951, the United Kingdom was allotted 81,465 long tons, which, according to British spokesmen, was a full 30,000 tons short of requirements, even on an austerity basis. Britishers began grimly predicting that the curb on U. S. sulphur shipments would result in a prompt 20 to 40% cut in the nation's rayon production. At the same time, J. Arthur Rank's Denham Film Laboratories—which handle about half of Britain's film printing—announced that the sulphur famine, by sharply curtailing the output of photographic chemicals, would shortly bring to a halt production in large segments of the nation's motion picture industry. Then in March, Washington granted the United Kingdom an additional sulphur quota of 19,000 long tons—an action which succeeded in quieting, at least temporarily, a few of the anguished cries from abroad.

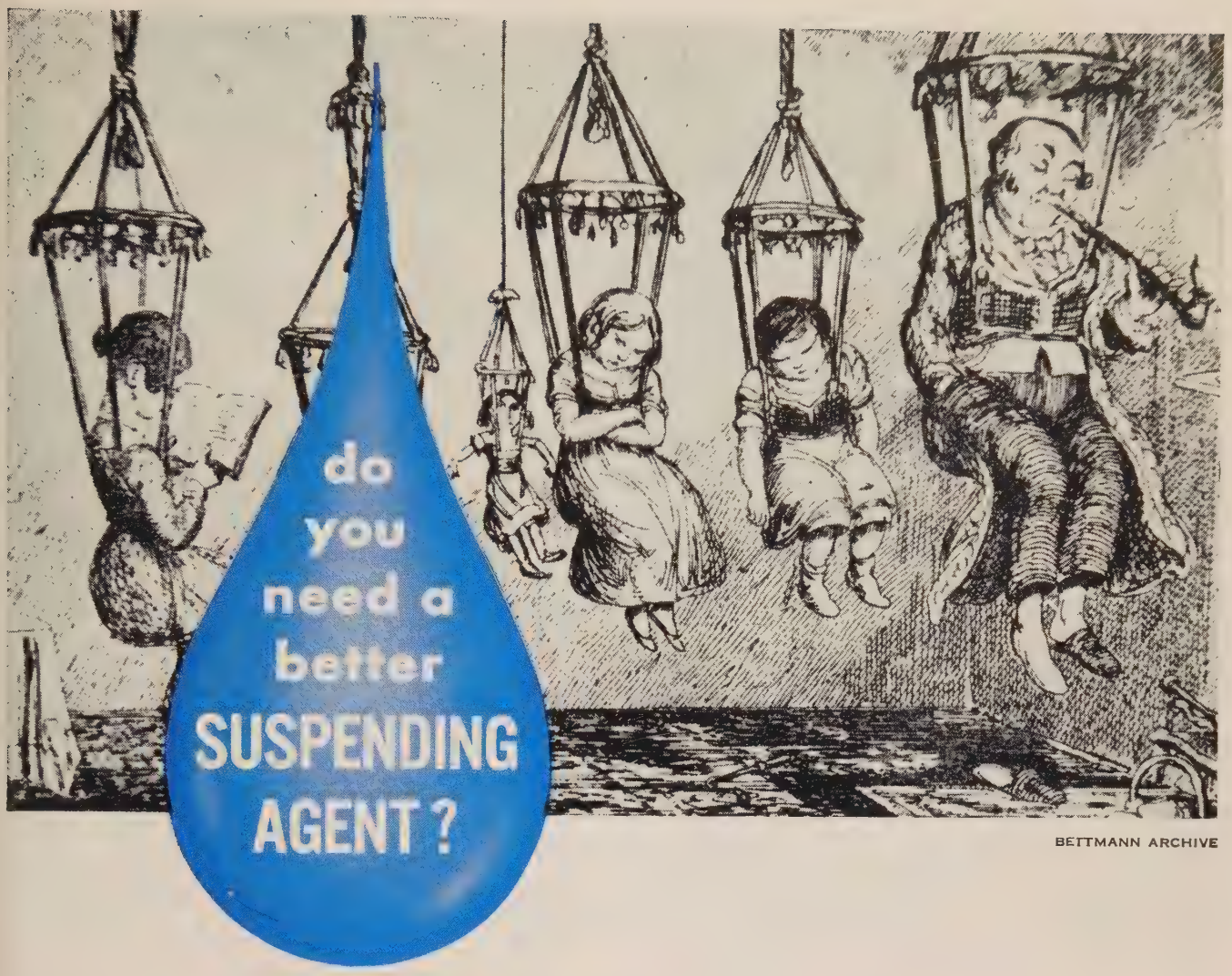
To the tune of "charity begins at home," some spokesmen in this country have been advocating that the United States reduce its sulphur exports even more drastically—and the sooner the better. Would such a policy be sound? Said one leading sulphur manufacturer: "With production outside of the United States insufficient to take care of the demands of the rest of the world, a severe reduction in sulphur exports now would mean an almost immediate breakdown in industrial activity in many foreign countries. Without doubt, such a foreign collapse would have an extremely damaging effect upon the economy of the United States."

FOREIGN OUTLOOK

The world-wide sulphur shortage has made its impact upon the Italian supply. Stocks are reported to be a mere 25,000 tons, or 17% of what they were at the end of 1949. In the coming years, Italy will spend about $15 million on mine development and drilling in an effort to boost its annual sulphur output from its present level of 250,000 tons to 400,000 tons by 1954.

Italians have long employed antiquated, highly inefficient methods in processing their native sulphur. For example, the heat required in the melting step is ordinarily obtained by the burning of the sulphur itself—a practice which commonly results in a 30 to 40% sulphur loss. However, some immediate improvements are in sight. Reports are that a flotation plant, employing U. S. machinery and purchased with American aid, will soon be in operation at Sicily's Cosso Disi mines. Anticipated sulphur yield: 90 to 95%.

Before World War II, Norway, surpassed only by Spain and Japan, was the world's third largest source of pyrites. While the nation is estimated to have a pyrites mining capacity of more than 1.4 million metric tons, only about half that tonnage has annually been produced during the past few years. Norway's proved and estimated reserves of pyrites total approximately 56



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million metric tons, of which the Grong deposits of about 30 million metric tons have never been touched.

Prior to World War II, Europe produced substantial quantities of sulphur from Spanish pyrites. However, during the past few years, Europe has turned increasingly to U. S. sulphur, while at the same time allowing its pyrites industry to slip into the background. The production of Spanish pyrites is today far below prewar standards. Output in 1950 was only 1.2 million metric tons, as contrasted with 2.7 million metric tons in 1938.

Said one congressional committee: "It is obvious that there has been no real effort on the part of the Economic Cooperation Administration to get European industry to use Spanish pyrites, rather than American sulphur as its source of sulphuric acid." On the other hand, ECA asserts that, as far back as 2 years ago, it had urged Europeans to switch to the use of Spanish pyrites, if only as a means of saving dollars. However, ECA never made much headway in its back-to-pyrites campaign principally because of the overwhelming appeal of cheap, readily available U. S. sulphur. On the other hand—what with the recent cutback in American sulphur exports—there is now, at long last, a decided move under way in Europe toward conversion to pyrites. Because such conversion will take at least 2 years to complete, prospects for the coming months are giving many a European industrialist a bad case of the jitters.

PRICE

Clearly, U. S. sulphur is dirt cheap. Current price to contract buyers: less than 1 cent a pound. Among the many singular virtues of U. S. sulphur is its price stability. Between 1935 and 1939, the price of crude sulphur was, on the average, $17.40 per long ton. By early 1950, the price of the same sulphur had risen almost imperceptibly to $18 per long ton. Although late last year sulphur went up to $21 to $22 a long ton, the new price represented a very modest 21 to 26% increase over the 1935–39 average. During the same interval, the average of all wholesale prices had shot up 118%.

GOVERNMENT ACTION

At the end of March, the National Production Authority began working up an allocation schedule for sulphuric acid. By mid-April, the order was out. It specified that no company in Arizona, California, Colorado, Idaho, Montana, Nevada, New Mexico, Oregon, Utah, Washington, and Wyoming may use or deliver sulphuric acid without specific authorization from the National Production Authority. Companies that purchase 60 tons of acid or less a month are exempt. The 11 western states covered by NPA Order M-45, Schedule 3, have been among those most severely affected by the nation-wide sulphuric acid scarcity. Hardest hit have been western manufacturers of fertilizer and high-octane gasoline.

The new order further provides that purchasers in all parts of the country must henceforth tell their suppliers exactly how they propose to use their sulphuric acid. In turn, the suppliers must pass along this information to NPA. For the time being, specific authorization for the delivery or use of sulphuric acid is required only in the 11 named western states. However, the reporting mechanism has been set up for all states not only to enable NPA to determine with some precision the national end-use pattern for sulphuric acid, but to permit the agency ultimately to devise a method by which sulphuric acid may be regulated on a nation-wide scale.

Several months ago, the Defense Minerals Administration was authorized to lend financial assistance to prospectors and mine operators as a means of stimulating the exploration of new ore deposits. The assistance takes the form of government loans repayable from the net returns from any ore, concentrate, or metal that may be produced. Government aid in all cases is a fixed percentage of the total cost of an approved project. The percentage depends upon the mineral; in the case of sulphur, the Government's contribution is 50%.

Early this year, the State Department called together an International Materials Conference to work out plans for increasing the production of 12 strategic raw materials. On March 1, the sulphur committee, composed of representatives from Australia, Belgium (for the Benelux countries), Brazil, Britain, Canada, France, Italy, New Zealand, South Africa, and the United States, began its deliberations. Still in session, the sulphur committee, like the conference's other five commodity groups, will pass along its specific proposals directly to each of the governments participating in the Washington parley.

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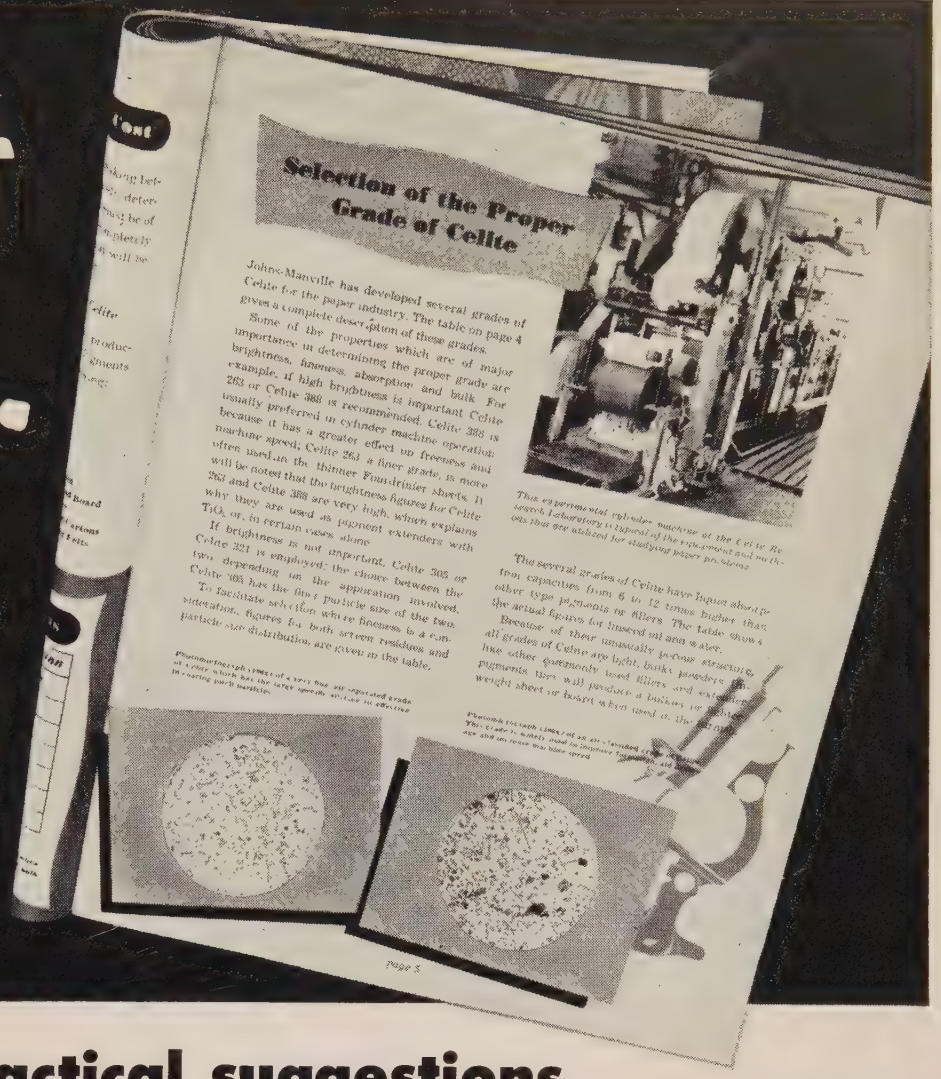
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page 5

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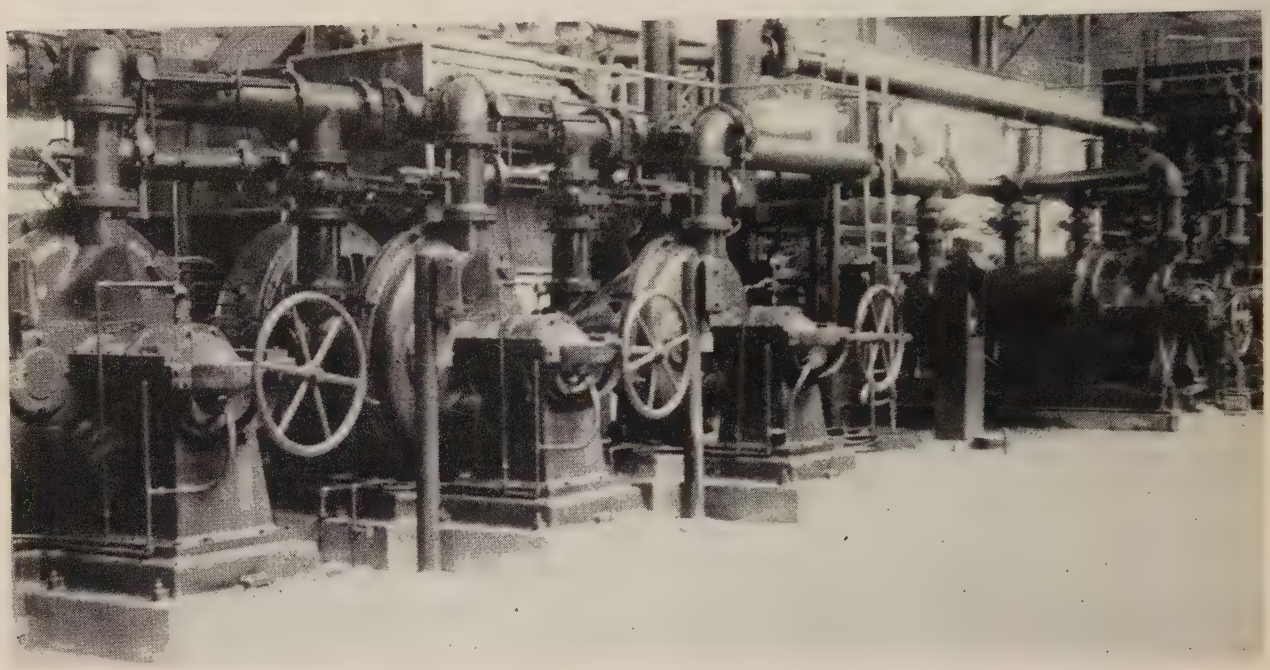

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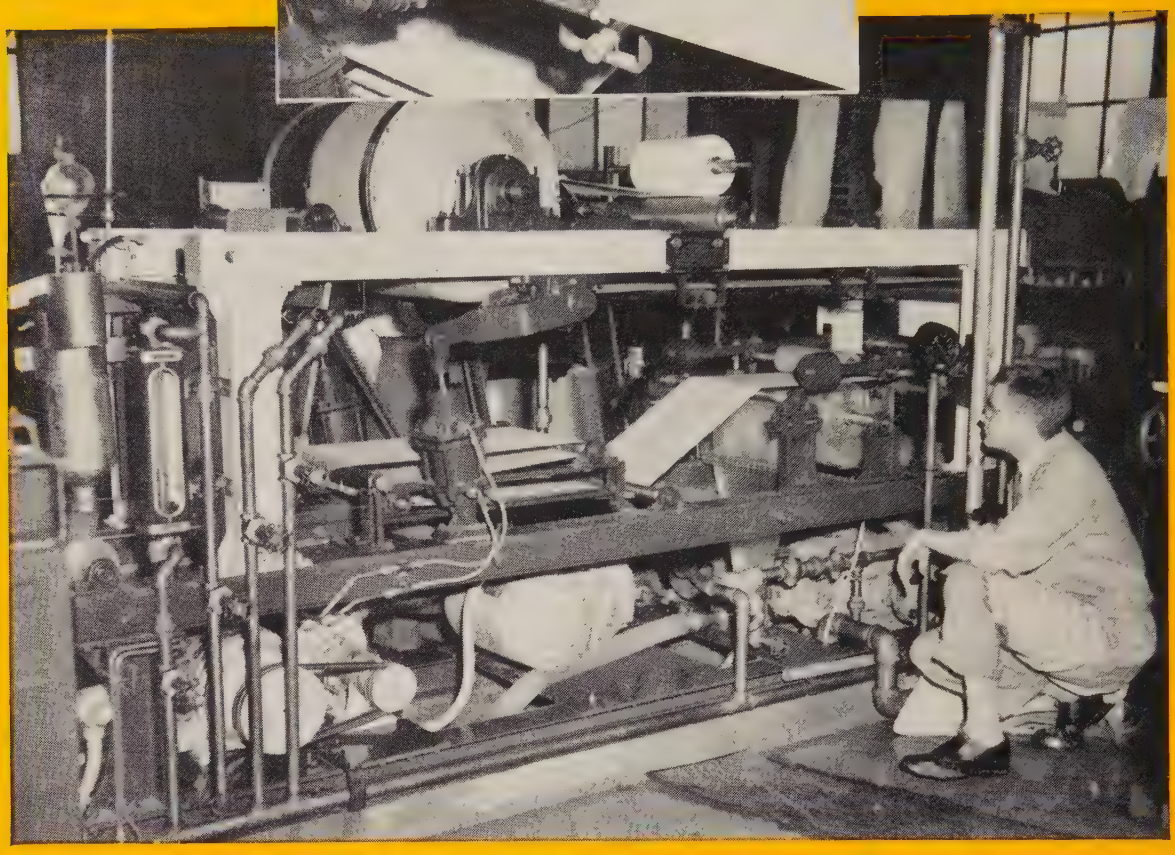

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The Colorimetric Determination of Hydrogen Sulphide and Methyl Mercaptan in Sulphate Pulp Mill Effluents and of Sodium Sulphide in Black Liquor

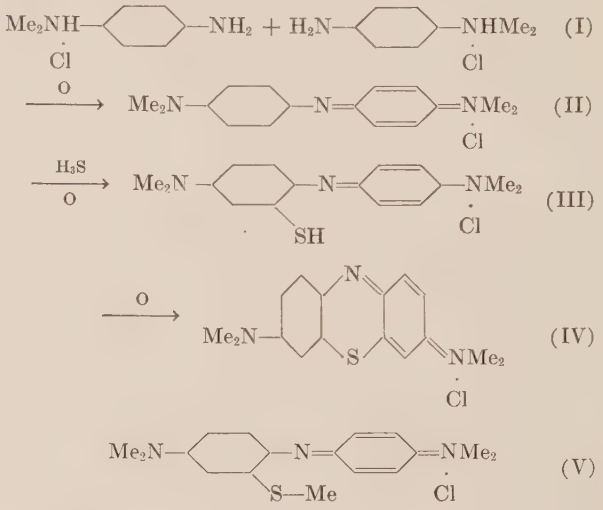
R. H. WRIGHT, M. A. SCHOENING, and A. M. HAYWARD

A colorimetric method for the determination of hydrogen sulphide and methyl mercaptan has been based on their reactions with Bindschedler's green to form methylene blue and a pink substance, respectively. Mercaptan does not seriously interfere with the determination of hydrogen sulphide. Interference of hydrogen sulphide in the determination of methyl mercaptan is prevented by adding cadmium chloride to the reagent and filtering before developing the color. A convenient absorption apparatus is described for sampling gaseous effluents. For the colorimetric determination of sodium sulphide in black liquor, adsorption of methylene blue by precipitated black liquor solids can be prevented by adding a suitable cationic wetting agent to the reagent.

As is well known, sulphate pulp mills give rise to a considerable odor nuisance due principally to the liberation of hydrogen sulphide and, more particularly, methyl mercaptan, together with lesser amounts of organic sulphides. The odor thresholds of these substances in air are of the order of 1 microgram per liter (*5*). The methods used for estimating the amounts of these substances in the mill effluents must therefore be highly sensitive. They must also be simple to be useful in field investigations.

The colorimetric determination of sulphide sulfur based on the formation of methylene blue has long been known (*1*). As generally carried out the alkaline sulphide solution is acidified with hydrochloric acid and dimethyl *p*-phenylene diamine is added followed by ferric chloride solution as an oxidizing agent. This produces methylene blue. Recent work (*3, 6*) indicates that this method can be made quantitative, and that mercaptans give a pink or red color which does not interfere with the determination of sulphide provided a spectrophotometer or adequate optical filter is used.

When dimethyl paraphenylene diamine is used for the colorimetric detection of sulphide the reactions are reported to be as in equations I, II, III, and IV (*4*):



The intermediate product II is Bindschedler's green. Methylene blue (IV) can also be prepared directly from Bindschedler's green by reaction with hydrogen sulphide in the presence of oxidizing agents.

It seemed probable that methyl mercaptan would behave similarly to give the corresponding intermediate product (see equation V) but that the presence of the methyl group attached to the sulphur would prevent continuation of the reaction as in stage IV above. Moreover, compound V should be colored.

While the same product might well be formed from dimethyl *p*-phenylene diamine, it seemed likely that more clear-cut reactions would be obtained starting with Bindschedler's green, and experiment showed that better colors were, in fact, obtained from it. Furthermore, the ready decomposition of Bindschedler's green by strong acids makes it easy to destroy excess reagent.

A very simple and convenient method for the quantitative estimation of both hydrogen sulphide and methyl mercaptan was developed which can be extended to include the determination of sodium sulphide in black liquor.

PREPARATION OF BINDSCHEDLER'S GREEN

Dimethyl aniline (21 grams) and *p*-amino dimethyl aniline hydrochloride (27 grams) were dissolved in 240 ml. of a mixture of equal volumes of concentrated hydrochloric acid and water. The mixture was placed in an ice bath and stirred mechanically. A solution of 30 grams of sodium dichromate in 60 ml. of water was added slowly from a dropping funnel at a rate such that the temperature remained constantly below 10°C. A precooled solution of 30 grams of zinc chloride in 60 ml. of water was then added a little at a time. Following the first addition of zinc chloride the walls of the beaker were well rubbed with a glass rod to start crystallization. Without this precaution, the solution tended to become supersaturated and later deposited the product in sticky masses which could not be washed and dried satisfactorily. Following the addition of the zinc chloride the stirring was continued vigorously for 30 minutes. The preparation may be interrupted at this point if the mixture is stored in a refrigerator at 3°C. overnight.

R. H. Wright, Member TAPPI; Head Division of Chemistry; M. A. Schoening, Junior Chemist, and A. M. Hayward, Junior Chemist, British Columbia Research Council, Vancouver, B. C.

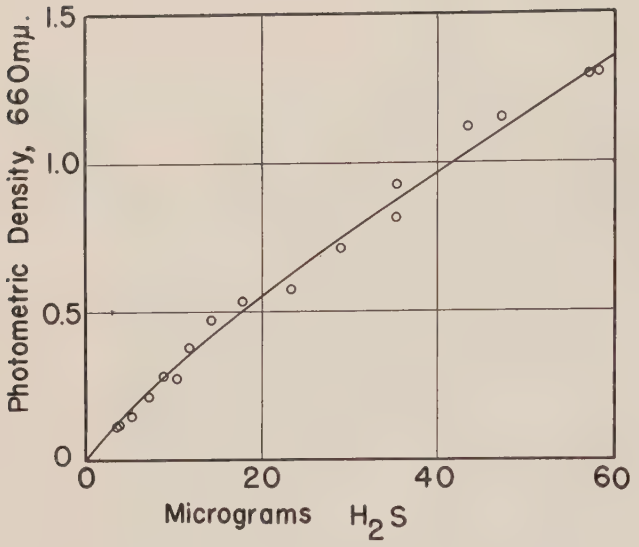


Fig. 1

The Bindschedler's green was collected on a Buchner filter and immediately redispersed in 50 ml. of water, the temperature being kept below 5°C. The solid was once more filtered and the filter cake again washed in the same way with a further 50 ml. of water. The crystals were then washed in the same way with three 50-ml. portions of 95% ethanol and three 50-ml. portions of ether, the mixtures in every case being cooled to or below 5°C. before filtering.

The crystals were spread out on a watch glass and dried for about 2 hours at a temperature of approximately 50°C. and then over silica gel in a vacuum desiccator for several days. The product was stored in well-stoppered bottles in a refrigerator until required. Yield is about 30 grams.

PREPARATION OF STANDARD SOLUTIONS

Since aqueous alkaline solutions of sodium sulphide and methyl mercaptan are gradually oxidized by the air, all standard solutions were prepared and stored in ampul vials or serum bottles sealed with rubber caps and the solutions were measured and transferred by means of hypodermic syringes.

To prepare a standard solution of sodium sulphide a 60-ml. vial was filled with fifth normal sodium hydroxide solution and nitrogen from a cylinder was bubbled through for several minutes to reduce the oxygen content. The rubber cap was then put on and a suitable volume (20 to 200 ml.) of gaseous hydrogen sulphide from a cylinder was injected into the vial with shaking, using for the purpose a large (100-ml.) hypodermic syringe fitted with a 25-gage, $^1/_2$-inch needle. Methyl mercaptan solutions were prepared in the same way. Gaseous methyl mercaptan was generated by warming a mixture of 27.8 grams of methyl isothiourea sulphate (dissolved in 65 ml. of water) with 20 grams of sodium hydroxide (dissolved in 100 ml. of water) in an apparatus previously swept out with nitrogen.

To standardize the solutions, a 10-ml. hypodermic syringe was used to withdraw a measured volume of solution from the vial and inject it below the surface of an excess of decinormal iodine solution acidified with hydrochloric acid. The excess iodine was then titrated to a starch end point with decinormal thiosulphate and the concentration calculated from the equations:

$$H_2S + I_2 \rightarrow 2HI + S$$
$$\text{or } Na_2S + I_2 \rightarrow 2NaI + S$$
$$\text{and } 2CH_3SH + I_2 \rightarrow 2HI + (CH_3)_2S_2$$

It was found that sulphide and mercaptan solutions would maintain their strength for months when preserved in properly sealed serum bottles and transferred with hypodermic syringes, provided the syringes were rinsed with nitrogen before use and provided the solution withdrawn was replaced by the equivalent volume of nitrogen.

The use of serum bottles and hypodermic syringes in this procedure has been found extremely convenient. For handling small volumes of liquid, 1-ml. insulin syringes graduated to $^1/_{40}$ ml. are suitable. The needles should be about 25 gage and $^1/_2$ or $1^1/_2$ inches long.

DETERMINATION OF HYDROGEN SULPHIDE

Reagents

1. Sodium hydroxide solution, $N/5$.
2. Bindschedler's green 0.400 gram in 250 ml. water. Freshly prepared each day.
3. Hydrochloric acid, $2\,N$.
4. Ferric chloride solution, $N/10$.

Procedure

Mix 10 ml. of Bindschedler's green solution with 10 ml. of hydrochloric acid by pouring back and forth between two test tubes. Immediately inject $^1/_8$ to $^1/_2$ ml. of test solution, accurately measured, into the mixed reagent. Place the test tube in an actively boiling water bath for 10 minutes to destroy the excess Bindschedler's green. Cool the mixture and add 1 drop of ferric chloride solution. Measure the optical or photometric density of the liquid, if necessary accurately diluting an aliquot with distilled water. The density should be measured against a blank containing the same reagents but with no added sulphide. Determine the amount of hydrogen sulphide from a calibration curve prepared by taking known amounts of standard sodium sulphide solution. The curve shown in Fig. 1 was obtained using an Evelyn photoelectric colorimeter with a 660 filter.

Notes

The Bindschedler's green solution should be freshly prepared each day.

The test solution should be added to the acidified Bindschedler's green as soon as possible after adding the acid. Owing to the speed with which Bindschedler's

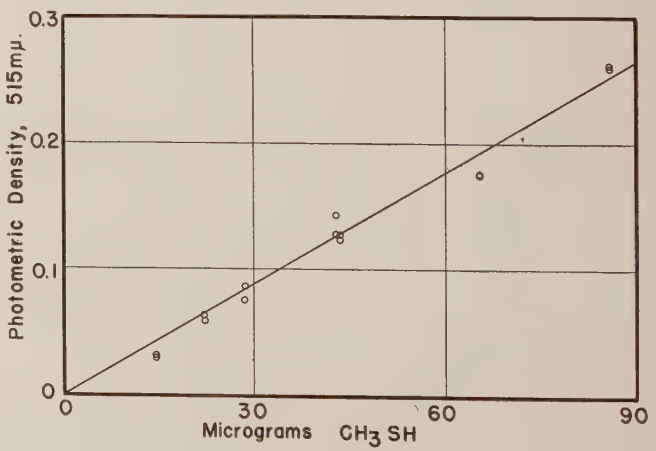


Fig. 2

green is destroyed by acids, even at room temperature, a significant error may be introduced by a delay of 2 minutes.

The addition of ferric chloride solution at the end of the test normally makes no difference to the color. With defective preparations of Bindschedler's green, the addition of ferric chloride develops or intensifies the color. Provided the intensification observed is not very great, the results may be taken as approximately correct. The principal reason for adding the ferric chloride is to show that the Bindschedler's green used is working correctly.

The optical density may be measured with a spectrophotometer or with a colorimeter using a filter transmitting in the region of 660 to 670 mmu.

The absorption curve of methylene blue shown in Fig. 3 was determined with a Model DU Beckman spectrophotometer.

DETERMINATION OF METHYL MERCAPTAN

Reagents

1. Sodium hydroxide solution, $N/5$.
2. Bindschedler's green, 0.400 gram in 250 ml. of water, freshly prepared.
3. Cadmium chloride solution, 100 grams $CdCl_2 \cdot 2^1/_2H_2O$ in 1000 ml. of 0.2 N hydrochloric acid.
4. Hydrochloric acid solution, 2 N.

Procedure

Mix 5 ml. of Bindschedler's green solution with 5 ml. of acidified cadmium chloride solution in a test tube. Immediately introduce $^1/_8$ to $^1/_2$ ml., accurately measured, of the test solution into the mixed reagent and filter through paper. Wash with 1 or 2 ml. of water and to the filtrate add 5 ml. of 2 N hydrochloric acid. Destroy the excess Bindschedler's green by heating the test tube in an actively boiling water bath for precisely 5 minutes. Cool the solution, bulk to 20 ml. (or more) with water, and measure its optical or photometric density in the vicinity of 500 mmu within 2 hours. Determine the concentration of methyl mercaptan by means of a calibration curve prepared by testing solutions of known composition in the same way. See Fig. 2.

Notes

Unlike the determination of hydrogen sulphide, the mercaptan analysis is very sensitive to variations in

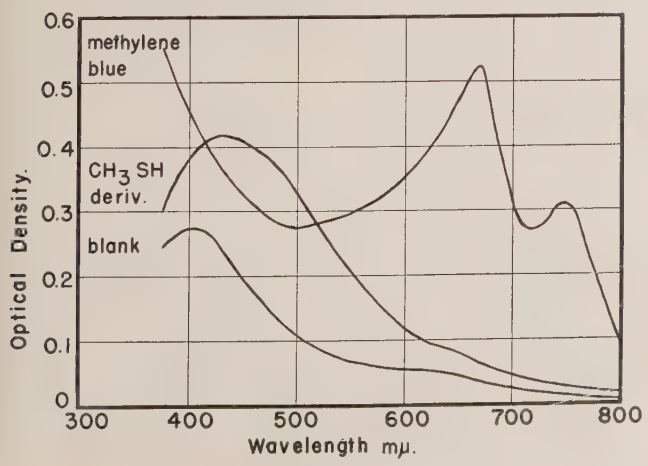


Fig. 3

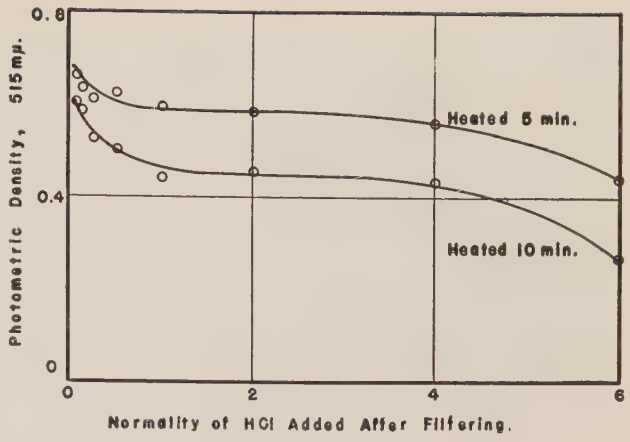


Fig. 4

the conditions, and therefore the procedure as outlined should be followed as exactly as possible.

The addition of slightly acidified cadmium chloride solution to the Bindschedler's green serves to eliminate interference by hydrogen sulphide. Cadmium sulphide is precipitated quantitatively and removed in the filtration. With higher acid concentrations cadmium sulphide is not quantitatively precipitated. Figure 4 shows the effect of adding various concentrations of hydrochloric acid after the filtration and also the effect of the time during which the mixture is heated to decompose excess Bindschedler's green.

After cooling the reaction mixture the optical density should be measured within about 2 hours since the color alters slowly on standing.

The absorption curves of the pink substance and of the blank are shown in Fig. 3. Best results in the determination of mercaptan will be obtained from observations of the optical density in the region 475 to 500 mmu. Entirely satisfactory results were obtained using a colorimeter fitted with a filter transmitting in the vicinity of 515 mmu.

MUTUAL INTERFERENCE OF MERCAPTAN AND HYDROGEN SULPHIDE

The optical absorption curves shown in Fig. 3 indicate that the presence of mercaptan should produce little interference in the determination of sodium sulphide or hydrogen sulphide unless the mercaptan were present in very large excess. This was borne out by adding varying amounts of mercaptan to solutions containing known concentrations of sodium sulphide.

From Fig. 3, methylene blue shows an appreciable absorption in the vicinity of 500 mmu. Hence, unless hydrogen sulphide is removed by cadmium chloride it would introduce a considerable error. Addition of sodium sulphide to the standard mercaptan solutions showed that under the conditions given the interference was negligible.

DETERMINATION OF HYDROGEN SULFIDE AND METHYL MERCAPTAN IN GASEOUS EFFLUENTS

For the determination of hydrogen sulphide and methyl mercaptan in gaseous effluents, a prior absorption of these substances is required. After trying various absorbents, $N/5$ sodium hydroxide solution was found the most convenient. With the technique given below, the loss through oxidation is negligible providing the colorimetric analysis is completed within about 1 hour of taking the sample.

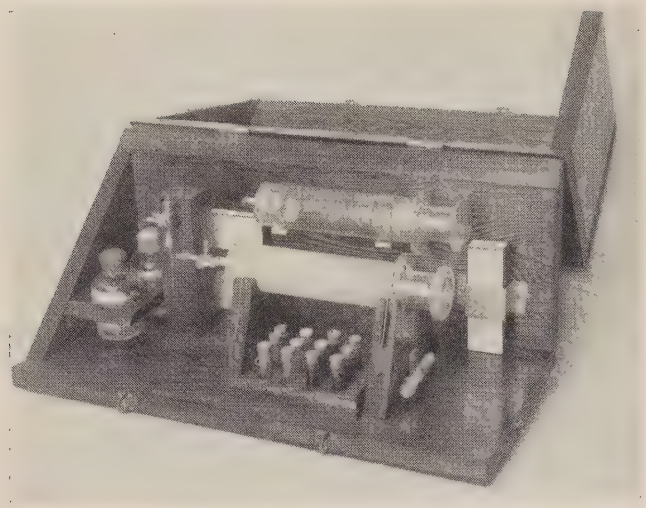


Fig. 5

For field determinations, the portable absorption apparatus shown in Fig. 5 was used. Mounted on the base of the box is a 100-ml. hypodermic syringe. Attached to the end of the syringe is a three-way tap as shown in Fig. 6. (These taps with standard taper fittings are available from medical supply houses.) Attached to the tap is a $^1/_2$-inch hypodermic needle bent to a right angle. A second three-way tap is mounted so that a 1.5-inch needle lies close to the short bent needle. A 2-ml. rubber-capped serum bottle containing 1 ml. of $N/5$ sodium hydroxide may be impaled on both needles as shown in Fig. 6. By appropriate manipulation of the three-way valves and the plunger of the syringe, a measured volume of gas may be drawn slowly as a stream of very small bubbles through the liquid in the vial. It was shown in a special experiment that one passage through such a vial was sufficient to absorb the hydrogen sulphide from an air stream.

As can be seen from Fig. 5, the portable absorption kit includes a variety of spare parts together with a 1-ml. hypodermic syringe used for filling the 2-ml. absorption vials.

The procedure used in taking a sample is as follows: Using a 1-ml. hypodermic syringe, 1 ml. of $N/5$ sodium hydroxide solution is transferred from a sealed stock vial to a small absorption bulb. The sodium hydroxide should be made up and bottled in an atmosphere uncontaminated by hydrogen sulphide or methyl mercaptan. The small absorption vial is then impaled on the two needles of the absorption apparatus as shown in Fig. 6 and a measured volume of gas is drawn through it in a slow stream. The sampling line leading to the absorption apparatus may be purged by temporarily connecting the side arms of the two three-way valves with a rubber tube and manipulating the syringe.

Where the concentration of hydrogen sulphide or mercaptan is very small, as much as 1 liter of gas may be drawn through the absorbing solution. Where the concentrations are very high, it may be desirable to use a larger volume of absorbing solution, say 10 ml., rather than to use a very small volume of gas. In this event, the small absorbing vial may be replaced by a 10-ml. insulin vial containing 10 ml. of the $N/5$ sodium hydroxide solution.

The solution in the absorbing vial may be analyzed for hydrogen sulphide and mercaptan by the colorimetric method described above. In order to minimize the loss due to combination with dissolved oxygen, it is desirable that the analysis be carried out within the hour.

GENERAL DISCUSSION

The procedures given above can be used for determining the hydrogen sulphide and methyl mercaptan concentrations of gaseous and liquid effluents provided they do not contain appreciable amounts of black liquor solids. Since 1 ml. of alkali solution is used for absorbing the hydrogen sulphide and mercaptan from the gases and in general only $^1/_8$ to $^1/_2$ ml. is used in each analysis, it follows that the same absorbing solution can be used for the determination of both mercaptan and hydrogen sulphide in the gases.

In sampling gaseous effluents, the time required to draw 100 ml. of air through the absorbing vial is of the order of 1 to 2 minutes. It is therefore possible to follow changes in the amounts of hydrogen sulphide and methyl mercaptan contained in such transient effluents as digester relief and blow gases, etc.

The chemical manipulations are simple and, with the exception of the photoelectric colorimeter, the apparatus required is simple and readily portable.

The sensitivity is reasonably good. Thus, from Fig. 1 a photometric density of 0.1 corresponds to 3 micrograms of hydrogen sulphide. If this reading is obtained with $^1/_8$ ml. of test solution, the total hydrogen sulphide absorbed in 1 ml. is 24 micrograms. If the volume of gas passed through the absorber was 100 ml., such a reading would correspond to 240 micrograms of hydrogen sulphide per liter. This may be described as the

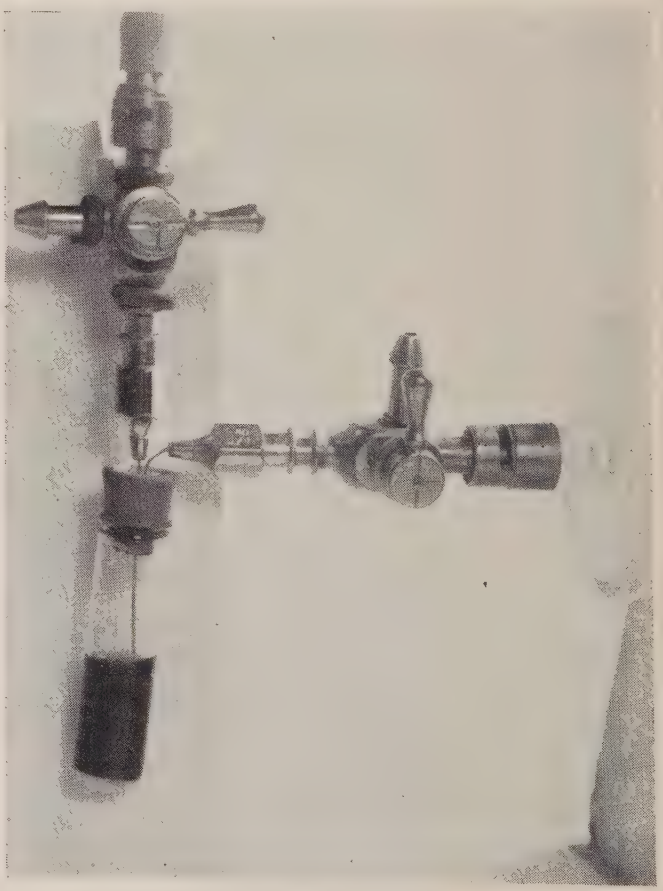


Fig. 6

normal range of the procedure. With a very low intensity source, the volume of gas drawn through the absorber may be 500 ml., and instead of $^1/_8$ ml. of test solution, $^1/_2$ ml. may be taken. Under these conditions a photometric density of 0.1 would correspond to 12 micrograms of hydrogen sulphide per liter. Since photometric densities materially less than 0.1 can be read, it may be concluded that the sensitivity of the method for hydrogen sulphide corresponds fairly closely to the sensitivity of the human nose itself. The threshold concentration of hydrogen sulphide is given as about 1 microgram per liter (*5*).

Similarly for methyl mercaptan, from Fig. 2, a photometric density of 0.1 corresponds to 34 micrograms mercaptan. In the normal range of the procedure this would correspond to 2700 micrograms of methyl mercaptan per liter of air. For low intensities where the gas sample is increased to 500 ml. and the test solution to $^1/_2$ ml., a density of 0.1 would correspond to a concentration in the air of 135 micrograms per liter. The sensitivity of the procedure for mercaptan is thus about $^1/_{12}$ of that for hydrogen sulphide but still sensitive enough for the purpose in view.

Since both the size of the gas sample and the fraction of the absorbing solution used in the analysis can be varied to match the intensity of the effluent being studied, the method is very flexible.

The specificity appears to be reasonably good. The principal substance likely to give false positive values for hydrogen sulphide is elemental sulphur. At various times during the development of the procedure, ferric chloride, sometimes in appreciable amounts, was added to the reagent before the introduction of the test solution. In view of the speed with which ferric chloride in acid solution oxidizes hydrogen sulphide to sulphur, it is almost certain that some oxidation took place in the reagent. The fact that such prior additions of ferric chloride made little noticeable difference to the result suggests that methylene blue can be formed equally well from hydrogen sulphide or from sulphur, or that free sulphur is an intermediate in the process whereby hydrogen sulphide and Bindschedler's green react.

Similarly, prior additions of ferric chloride do not affect the determination of mercaptan. Since methyl mercaptan is readily oxidized to dimethyl disulphide, it is possible that the disulphide also is capable of producing the pink coloration. This would not be a serious defect since the amount of dimethyl disulphide present

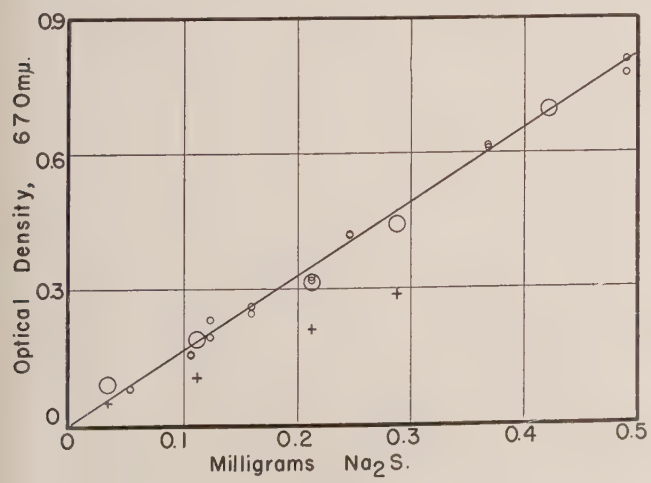


Fig. 7

Fig. 8

under plant conditions would probably be small and the fact that it has an odor of its own would justify its inclusion with the mercaptan. Dimethyl sulphide will probably not react and hence there is no provision for including it in the procedure. The specificity of the procedure for methyl mercaptan has not been examined. It seems probable that other mercaptans would react similarly.

DETERMINATION OF SODIUM SULPHIDE IN BLACK LIQUOR

Since black liquor solids are precipitated by acids, an attempt was made to determine the sodium sulphide content of black liquor by the colorimetric method.

When some samples of black liquor were injected directly into the mixture of Bindschedler's green and 2 *N* hydrochloric acid solution the colorimetric sodium sulphide concentration was in good agreement with the value found by the ammonium chloride evolution method (*2*). With other samples of black liquor, however, the colorimetric method gave low results.

It was found that the precipitated black liquor solids can adsorb methylene blue. The adsorption can be prevented by adding to the reagent a cationic wetting agent. The particular wetting agent used was an alkyl dimethyl benzyl ammonium chloride manufactured by Onyx Oil and Chemical Co. (The alkyl is described as being primarily *n*-$C_{12}H_{25}$— with homologs from C_8H_{17}— to $C_{18}H_{37}$—. The material is supplied as a 50% solution.) While other cationic wetting agents were not tried, it seems likely that they would exert a similar action.

Since the wetting agent is precipitated in high concentrations of acid, the hydrochloric acid used in the test must be reduced to *N*/2 instead of 2 *N*. On account of the reduction in acidity, the heating time used to decompose the excess Bindschedler's green should not be less than 10 minutes. The amount of wetting agent used is not critical and 50 drops of the 50% solution added to 500 ml. of *N*/2 hydrochloric acid is satisfactory.

The black liquor solids and the wetting agent mutually coagulate each other forming a gummy mass which becomes attached to the wall of the test tube. The test solution can therefore be decanted away from the precipitate as soon as it has cooled and there is no need to filter the mixture.

Following is the procedure for determining sodium sulphide in black liquor:

Reagents

1. Bindschedler's green—0.400 gram per 250 ml. water, freshly prepared.
2. Hydrochloric acid—$N/2$ containing 50 drops of alkyl dimethyl benzyl ammonium chloride (50%) in 500 ml.
3. Ferric chloride—0.1 N.

Procedure

Mix 10 ml. of Bindschedler's green solution with 10 ml. of hydrochloric acid. Immediately add $^1/_8$ ml. of black liquor and stir. Heat in a boiling water bath for 10 minutes. Cool and decant the liquid. Make up to 100 ml. with distilled water and add 2 drops of ferric chloride solution. Measure the optical or photometric density at 670 mmu against a reagent blank solution as standard. From the calibration curve, Fig. 7, determine the amount of sodium sulphide in the sample.

In Fig. 7 the small circles indicate calibration points obtained with sodium sulphide solutions. The large circles indicate points obtained with sulphate black liquor whose sodium sulphide concentration had been determined by the ammonium chloride evolution method. The crosses indicate points obtained from black liquor by the same procedure but with the cationic wetting agent omitted from the reagent. These optical densities were measured with a Model DU Beckman spectrophotometer.

Since it is difficult to observe the position of the plunger of a hypodermic syringe when using black liquor, it is desirable to modify the syringe in the following way (see Fig. 8). A C-shaped brass collar is fastened to the barrel of the syringe with hard wax or DeKhotinsky cement, and a brass point is similarly fastened to the end of the plunger. By carefully filing down the end of the collar, it is a simple matter to adjust the syringe to contain any desired amount of black liquor when the end of the brass pointer is bearing on the collar. By rotating the plunger slightly so that the pointer enters the slot of the collar, a definite quantity of black liquor may be expelled from the syringe. For most black liquor analysis, $^1/_8$ ml. is a convenient amount.

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Seam Adhesives for Multiwall Bags

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The successful manufacture of multiwall bags is dependent to a large extent on the use of proper seam adhesives. These seam adhesives fall into three main classifications: (1) standard seam adhesives, (2) water-resistant seam adhesives, and (3) waterproof seam adhesives. Finding the best adhesive for each classification involves consideration of three types of factors: (1) physical, (2) chemical, and (3) psychological. The choice of a particular adhesive for each classification is often limited by the type of paper involved and by the effect of heat on the adhesive bond.

A SATISFACTORY adhesive for multiwall bags must form a bond that will be as strong as the paper under all conditions that the paper is required to withstand. Some of the conditions that papers are required to withstand are these: excessive moisture, heat, attack by bacteria, attack by rodents, action of molten asphalt and wax, attack by mild acids and alkalies, aging, action of various chemicals, attack by mold, and action of greases and oils. Of course, neither a single type of paper nor a single adhesive is required to withstand all of these conditions, but a combination of several is not uncommon.

In addition to these considerations in looking for a satisfactory adhesive there are several other extraneous factors which must be kept in mind. Machine operating conditions offer several limitations. The adhesive must have enough initial tack to hold the paper firmly until the adhesive dries and obtains its final set. It must be of the proper viscosity and have enough body to give a firm bond. The character of the tack, viscosity, and body must be such that it will transfer to the paper uniformly without skipping or throwing. It must not foam nor break down with agitation. It should not have a corrosive action on the bronze paste pots commonly used. It must not cause the paper to curl before the tube is properly formed.

Other limitations are these: the cost must not be prohibitive; the adhesive must have a fair storage life; if it is to be prepared at the bag plant it must be of simple formulation and it must not require elaborate equipment for preparation, and it must be a cold setting adhesive.

There are three major projects to be completed in order to establish a well-developed line of seam adhesives for multiwall bags. These projects are: (1) development of a standard seam adhesive, (2) development of a water-resistant seam adhesive, and (3) development of a waterproof seam adhesive.

In solving the contingent problems coincident with these projects the development chemist encounters and must thoroughly master three types of factors, namely, physical, chemical, and psychological.

The physical factors include cooking and handling equipment, machines using the adhesives, paper to which the adhesive is applied, and cost.

Development of seam adhesives for the multiwall bag plant of the Crown Zellerbach Port Townsend Division was done with a 300-gallon stainless steel cooker with a ribbon-type agitator. Heat was supplied

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by low-pressure indirect steam through the cooker jacket. Seam adhesives are normally pumped from storage tanks to the tube-making machines through iron pipe, but are often handled in steel drums and ladled into the machine paste pots. Occasionally direct steam is used to heat, thin, and break lumps in heavy or lumpy adhesives. The adhesives in question are used on two types of tube-making machines. The paper to which the adhesives are applied is chiefly unbleached natural kraft with small amounts of the following varieties being used from time to time: bleached kraft, colored kraft, asphalt laminated kraft, vegetable parchment, glassine, laminated glassine, various coated papers, creped kraft, wet-strength kraft, and wet-strength creped kraft. The cost per gallon of seam adhesives at the machines varies from a few cents to several dollars.

The chemical factors include the basic raw materials, chemical additives, cooking reactions, drying reactions, and reactions that occur during storage of prepared adhesives.

Basic raw materials used in seam adhesives are principally derivatives of raw starches. There are also various resin emulsions, such as polyvinyl acetate and latex that are extensively used. Utilization of chemical additives, such as caustic soda, borax, preservatives, and antifoam agents, gives particular effects that often make their use desirable and necessary. The reaction of paste materials during cooking, storing, using, and drying are affected by extraneous factors such as temperature, pH, contamination by foreign materials, agitation, and construction of the particular bag on which the adhesive is used.

The psychological factors arise from associations with the following personnel: bag plant supervisors, adhesive makers, machine operators, adhesive salesmen, and finished bag salesmen.

The work of the development chemist must be compatible with production processes in the bag plant. In other words, machine trials of new adhesives must not unduly interrupt bag production. The confidence of machine operators and bag plant supervisors can easily be lost by these interruptions or by too many trial failures. Tact and caution must be constantly practiced. The operators and supervisors are naturally production conscious and this fact should always be remembered when evaluating their opinions of the performance of an adhesive.

The man in the plant who actually cooks the adhesive is most often not technically minded and may lack appreciation for accuracy and close control of cooking conditions. This situation requires exacting supervision in order to evoke correct evaluations of the cooked adhesives.

Sales representatives from various starch and adhesive producers are valuable contacts for the development chemist; however, he must remember that it is his obligation to check product recommendations in order to determine if the recommendations will fit the particular conditions present in the characteristic operation of the individual plant. A product may be highly satisfactory in one plant and fail completely when used in the same operation at a different plant.

Personnel concerned with selling the finished bags should be educated in adhesive characteristics so that they will have an appreciation for the position of adhesive performance in the over-all production picture. They have the opportunity to obtain, and to pass on to the bag factory, information on what conditions the adhesive must withstand. If they have been informed of the capabilities and limitations of the stock adhesives available for bag making they can more logically prescribe the proper adhesive for the bag in question.

DEVELOPMENT OF ADHESIVES

The development of a standard seam adhesive occupies the paramount position for consideration. A standard adhesive is one that must form a bond that is stronger than the cross machine direction tensile strength of the paper bonded under normal conditions of temperature and humidity. Normal conditions of temperature and humidity shall be 40 to 100°F. and 20 to 99% relative humidity.

A standard adhesive is most often also a heat-resistant adhesive, which means that it must form a bond that will not fail at any abnormally high temperature that the bonded paper will withstand. This feature is at times an important consideration since products are often packed in multiwall bags at temperatures as high as 300°F.

The operators demand primarily a standard adhesive that will perform well at high machine speeds. Trade practices revealed by starch product salesmen indicated that corn dextrine is often used as a base material for adhesives of this type. Several varieties of this material and similar materials were obtained and worked into experimental formulations. These were tried on the tube-making machines in order to determine which would give the best operating performance. One particular formulation gave promising results using a commercially blended corn dextrine with borax. This formulation caused excessive foaming in the paste pan on one tuber, which was overcome by adding a small amount of an antifoam agent. The same adhesive at first appeared unsatisfactory for use on the other tuber because the higher speed of this machine caused the adhesive to be thrown from the bronze applicator wheels; however, this was alleviated by mechanical adjustment of the machine.

The borax in this adhesive causes an increase in "tackiness" or "grab" so that the seam is held firmly enough to prevent a loose-walled tube which results from slippage of the pasted seam after the tube leaves the formers of the tuber. The maximum amount of borax desirable will vary with the type of starch blend being used and if too great a percentage is added the *adhesiveness* of the product will change to *cohesiveness*. This cohesiveness, or "sticking to itself" characteristic will not allow the adhesive to transfer well to the paper and defective tubes will result.

The development chemist should be familiar with the effect of caustic soda on an adhesive. It has value as an additive to thicken an adhesive that may be too fluid. It will also aid the adhesive by "biting" into a highly sized paper so that a stronger bond will form.

Adhesives containing caustic soda or borax must be intelligently handled if plant operations are such that other special adhesives are used from time to time since these chemicals are not compatible with several resin-

type adhesives. A very small amount of contamination will cause gumming or jelling of the special adhesives.

A water-resistant adhesive is one that will form a bond that is stronger than the cross machine direction wet tensile strength of the paper after soaking the pasted seam for 1 hour in water at 73°F. This test may demand a different adhesive for each type of paper used; however, only two principal ones will be considered, namely, an adhesive used on natural kraft and an adhesive used on wet-strength kraft. When natural kraft paper is soaked in water for 1 hour there is very little strength retained and, consequently, the adhesive need not have excessive wet strength. On the other hand, when wet-strength kraft paper is soaked in water for 1 hour it retains nearly one-third of its original strength and, therefore, the adhesive must correspondingly retain more wet strength than one used on natural kraft.

The problem of making the adhesive bond insoluble was attacked with guidance and advice from technical sales representatives of several starch companies. The concensus of recommendations was in favor of using urea-formaldehyde as the insolubilizing agent for starch base adhesives. Library research also revealed that this was the most commonly used technique for solving the problem of water-resistant adhesive bonds. The reactions that render the bond insoluble are progressive and usually require 5 to 7 days "curing" time before the maximum water resistance is obtained. Heat accelerates the reaction so for test purposes a 1-hour oven cure at 220°F. is often used.

"The Chemistry and Industry of Starch" by R. W. Kerr (*1*) informs us that the bond of an adhesive made from raw starch is more easily rendered insoluble by the action of urea-formaldehyde resins than one made from a dextrine or partially converted starch. The higher the degree of dextrinization the more difficult is the job of insolubilizing. This bit of knowledge would seem to lead to the use of raw starch in the formulation of water-resistant adhesives; however, when an adhesive made from raw starch is adjusted to the proper viscosity for seam application the percentage of solids becomes so low that the bond will not be strong enough. Therefore, it is necessary to determine the point at which the per cent solids and degree of insolubility satisfy performance demands. This determination is made more difficult because the reaction between starch and urea-formaldehyde resins causes the adhesive to "set back" or become more viscous with age. In order to overcome this difficulty to some extent, four practices were adopted in the preparation of water-resistant adhesives from converted starches and urea-formaldehyde resins.

1. Usage of this type of adhesive was programmed so that storage time was at a minimum.
2. Maximum cooking temperature was increased 10 to 15° above normal.
3. The maximum cooking temperature was held for 20 to 30 minutes with agitation constant until the temperature dropped below 150°F.
4. The adhesive was used on the machines at elevated temperatures (100 to 160°F.) in order to get minimum viscosity at maximum per cent solids.

Close adherence to these practices will yield an adhesive that will easily meet the requirements for a water-resistant adhesive when bonding *natural* kraft and should also be satisfactory for bonding *wet-strength* kraft in the absence of extenuating factors.

A waterproof adhesive is one that will form a bond that is stronger than the cross machine direction wet tensile strength of the paper after soaking the pasted seam for 72 hours in water at 73°F. and will pull fiber over at least 75% of the bonded surface when peeled as specified in government specification UU-S-48a (*2*). Here again, as was the case with water-resistant adhesives, the suitability of the adhesive depends on the type of paper that is to be bonded.

The problem of finding an adhesive that will meet the established requirements for waterproof adhesives is easily solved if only natural kraft is to be bonded. The starch and urea-formaldehyde formulation will usually prove adequate. However, if it is necessary to bond wet-strength kraft so that specifications are complied with, the problem becomes much more severe.

The use of latex base and similar emulsions, with and without extenders, produces a bond that is extremely waterproof. This is gratifying and adequate until the additional requirement of heat resistance becomes prominent. The bond formed by latex emulsions tends to soften and fail at temperatures sometimes as low as 100°F. This characteristic puts a dangerous limitation on the use of an adhesive containing excessive amounts of latex emulsions or similar products.

The base material that has proved most satisfactory is a polyvinyl acetate-polyvinyl alcohol mixture. The seam formed by an adhesive containing this base material when properly formulated will produce a bond that is both waterproof and heat resistant when tested with wet-strength kraft paper. There is one item of caution to be observed in the use of an adhesive of this type—protection from cold. In many cases 40°F. is a low enough temperature to cause the emulsion to break down and become unfit for use as an adhesive.

SUMMARY

A survey of the material presented in this paper reveals the following points of information for anyone interested in seam adhesives for multiwall bags:

1. The adhesive bond, at all times, must be as strong as the paper involved.
2. Three types of factors enter for consideration in seam adhesive development work: physical, chemical, and psychological.
3. The stocked supply of seam adhesives should include a standard adhesive, a water-resistant adhesive, and a waterproof adhesive. They should all yield heat-resistant bonds.
4. A satisfactory standard adhesive which will allow tube-making machines to operate at maximum rates of speed can be made from blended corn dextrine.
5. An adhesive can be made from blended starches and urea-formaldehyde resins that will yield a satisfactory water-resistant bond even on wet strength kraft.
6. An adhesive with a polyvinyl acetate base will develop an extremely strong bond that is almost completely insoluble in water.

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The Development of Wet Strength in Neoprene-Containing Papers

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The results of several laboratory experiments made to investigate some of the variables which influence the development of wet strength in paper containing neoprene are presented. It is shown that the amount of alumina associated with the neoprene is important to the development of wet strength in paper. Best wet-strength results are obtained when the alum to neoprene ratio is maintained at 0.2 or above. Subjection of alumina-flocculated neoprene to alkaline pH values for brief intervals does not influence the wet strength but longer intervals (several days) at a pH of 8.0 appear to be detrimental to the development of wet strength. After wet strength has developed in the sheet, the alumina has served its purpose and may be removed without impairment of wet strength. Wet strength begins to develop in a sheet containing neoprene only after most of the water has been removed and a major part of the dry tensile has developed. The rate of development of wet strength increases with decrease in moisture content and with increasing temperature.

A PRACTICAL method of adding neoprene latex to the beater for the production of papers having unusual properties has been described by Walsh and coworkers (*1*). This method consists of the addition of a stable, but sensitized and compounded, neoprene latex to the pulp, followed by coagulation of the neoprene upon the fibers with aluminum sulphate.

One of the many interesting properties which these investigators showed to be imparted by the neoprene was high wet tensile strength. Data on 25 machine runs indicated a good deal of reliability for the neoprene latex treatment of the pulp. However, some poor results and some exceptionally good results were obtained. It was pointed out that any system as complicated as that used in papermaking undoubtedly involves many variables which alter the effectiveness of neoprene in papermaking. It is the purpose of this report to present the results of several laboratory experiments made to investigate some of the variables which influence the development of wet strength in paper containing neoprene.

EXPERIMENTAL PROCEDURES

Method of Addition of Neoprene to the Pulp

Consideration of the ways and means of investigating the several variables involved in the addition of neoprene to paper revealed that the sensitized method of coagulating neoprene in the presence of the pulp involves changes in concentration with the quantity of neoprene added to the pulp. Such changes in concentration at the time of coagulation were shown to give precipitated products having different particle sizes and it was expected that the particle size of neoprene might affect the retention and efficiency of neoprene in handsheets. Therefore, a new method of coagulation, referred to as the precoagulation technique, was developed. This laboratory technique involves coagulation of the compounded neoprene latex with alum prior to addition to the pulp. The precipitated or coagulated neoprene slurry may then be added to the pulp in any desired amount.

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Preparation of Precoagulated Neoprene and Handsheets

Twenty-five and three-tenths grams of Neoprene latex type 735 (8.0-gram solids) are added with stirring to a solution of 8.0 ml. of 10% Darvan No. 1 solution, 89.6 ml. of 2% sodium hydroxide, and 3630 ml. of water. Zinc oxide, antioxidant, and other compounding agents are added where desired. Approximately 244 ml. of 2.5% aluminum sulphate (C.P. hydrated) are added slowly to the mixture with continued stirring. Upon addition of the alum solution, the neoprene precipitates in the form of a fine floc. The final pH of the slurry should be 5.0. Aliquots of the neoprene slurry are added with stirring to pulp at 1.5% consistency as desired. The furnish is diluted to the desired consistency, usually 0.5%, and used for the preparation of handsheets on a Valley sheet mold in the regular manner.

The alpha pulp used in these investigations was beaten to a Schopper-Riegler freeness of 700 ml. in a Valley laboratory beater. The handsheets were made at a basis weight of 45 pounds (25 × 40—500).

The analysis of the handsheets for neoprene was carried out by the oxygen bomb method for the determination of chlorine.

A comparison of the precoagulation technique with the sensitized method of Walsh and co-workers revealed no appreciable differences in either retention of neoprene or wet-strength development. It is important to note that retention of flocculated materials is usually much poorer on a laboratory scale than in commercial operation because of the much lower pulp consistency and greater suction leg on the sheet mold normally employed. It should also be recognized that these same factors are responsible for large variations in the retention of neoprene in tests carried out in different laboratories. The quantity of neoprene in the sheet is the important factor and not the percentage retention.

The Effects of Alum and Alkali on the Wet-Strength Properties of Neoprene

Neoprene which has been prepared according to the precoagulation process contains a large amount of flocculent alumina in addition to the polymer. Microscopic examination at a magnification of 200× indi-

cates that the flocked neoprene particles are imbedded in a matrix of alumina. When the alumina content is low, the particles appear to be opaque; when the alumina content is high, the particles are translucent.

Both the sensitized and precoagulation methods of adding neoprene to papermaking pulps normally require the addition of zinc oxide as a compounding agent. Preliminary work indicated that a significant part of the zinc oxide reacts with the alum which is added to coagulate the neoprene and lowers the pH value. Because this factor appeared to be important to the retention and effectiveness of neoprene, experiments were performed with the precoagulation technique to investigate the effects of alumina upon the wet-strength properties of alpha pulp handsheets.

The normal quantity of zinc oxide added to the pulp was 15% (based upon the neoprene). In more recent commercial practice, 5% has been used. In certain instances, wherein the zinc oxide was left out, an equivalent amount of sodium hydroxide was used in its place in order that the same amount of alum would be used to lower the pH to 5.0. In other experiments, both zinc oxide and sodium hydroxide were used and only sufficient alum was added to lower the pH to 6.1 instead of the normal pH of 5.0. In still another case both zinc oxide and sodium hydroxide were left out; only sufficient alum to lower the pH to 5.0 was used and the coagulation was accomplished by the addition of sodium chloride. Wet strength was used as a measure of neoprene effectiveness. The data are presented in Table I and Fig. 1; they appear to support the following statements:

When the wet-strength data obtained under various conditions of coagulation are plotted against the quantity of neoprene retained in the sheet, two distinct curves result which illustrate conditions of high and low effectiveness of neoprene.

The coagulation of neoprene in the presence of zinc oxide with sufficient alum to lower the pH to 5.0 resulted in good retention and effectiveness of the neoprene. Similar results were obtained when an equivalent quantity of sodium hydroxide was substituted for the zinc oxide.

When zinc oxide was present and sufficient alum was used to lower the pH to 6.1, good retention but poor effectiveness of neoprene was noted. Further work showed that zinc oxide reacted very slowly with alum at a pH of 6.1. Thus, under the conditions of this experiment it appears that perhaps insufficient alumina

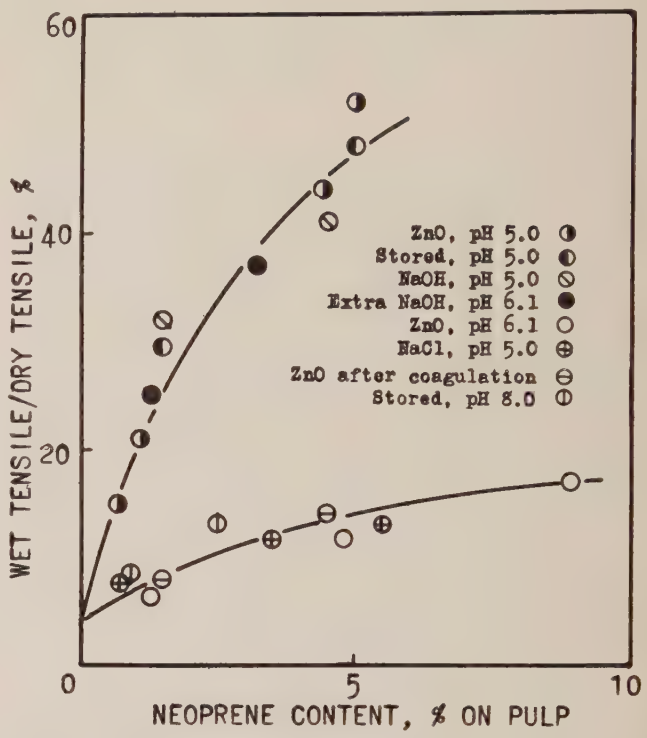

Fig. 1. Effect of coagulation conditions on wet strength produced by neoprene

Table I. The Effects of Alum and Alkali on the Retention and Effectiveness of Neoprene

Neoprene			Tensile strength, lb./in.		
Added, %	*Retained, %*	*Coagulation conditions*	*Dry*	*Wet*	*Wet/dry, %*
0	...	ZnO, alum to pH 5.0	15.6	0.6	4
3	1.1	ZnO, alum to pH 5.0	15.0	3.1	21
15	5.0	ZnO, alum to pH 5.0	14.3	7.4	52
3	0.7	ZnO, alum to pH 5.0	14.7	2.2	15
15	4.4	ZnO, alum to pH 5.0	15.8	6.9	44
5	1.5	NaOH, alum to pH 5.0	15.8	5.1	32
15	4.5	NaOH, alum to pH 5.0	18.1	7.4	41
0	...	Extra NaOH, alum to pH 6.1	16.3	0.7	4.3
5	1.3	Extra NaOH, alum to pH 6.1	14.9	4.0	25.0
15	3.2	Extra NaOH, alum to pH 6.1	16.4	6.1	37.0
0	...	ZnO, alum to pH 6.1	15.8	0.5	3.2
3	1.26	ZnO, alum to pH 6.1	14.1	0.9	6.4
10	4.83	ZnO, alum to pH 6.1	14.5	1.7	11.7
20	8.90	ZnO, alum to pH 6.1	14.1	2.4	17.0
0	...	No ZnO or NaOH, alum to pH 5.0 plus NaCl	14.9	0.7	4.7
5	0.74	No ZnO or NaOH, alum to pH 5.0 plus NaCl	14.4	1.1	7.6
15	3.52	No ZnO or NaOH, alum to pH 5.0 plus NaCl	14.5	1.7	11.7
20	5.53	No ZnO or NaOH, alum to pH 5.0 plus NaCl	14.5	1.9	13.1
0	...	NaOH, alum to pH 5.0, followed by ZnO	15.3	0.7	5
5	1.5[a]	NaOH, alum to pH 5.0, followed by ZnO	14.5	1.2	8
15	4.5[a]	NaOH, alum to pH 5.0, followed by ZnO	14.3	2.0	14
5	1.50	NaOH, alum to pH 5.0, stored 5 days	15.9	4.7	29.5
15	5.0	NaOH, alum to pH 5.0, stored 5 days	17.7	8.5	48.0
5	0.9	NaOH, alum to pH 5.0, NaOH to pH 8.0, stored 5 days	15.2	1.3	8.6
15	2.5	NaOH, alum to pH 5.0, NaOH to pH 8.0, stored 5 days	16.0	2.1	13.1

[a] Estimated.

is present or that the higher pH may have a detrimental effect upon the development of wet strength.

Coagulation of neoprene latex in the absence of either zinc oxide or sodium hydroxide (by the addition of sodium chloride and a very small amount of alum to lower the pH to 5.0) gave fairly good retention but poor neoprene effectiveness. This precoagulated neoprene was very tacky and had a strong tendency to agglomerate upon standing.

The addition of zinc oxide to a normal precoagulated neoprene prepared in the absence of zinc oxide (but with the equivalent quantity of sodium hydroxide plus alum to pH 5.0) resulted in poor neoprene effectiveness. It is important to note that the pH of this precoagulated latex rose to 8.3 soon after addition of the zinc oxide. These data indicate further that alkaline conditions may be detrimental to the development of neoprene wet strength.

In order to investigate further the matter of alkalinity, experiments were performed with a normal precoagulated neoprene wherein the pH in the headbox was varied between 5.0 and 8.9. These experiments indicated that momentary alkaline pH values at the headbox, when the handsheet is formed, do not seriously influence the wet strength. However, considerations of the gross mechanism of neoprene coagulation and the rather brief interval during which the neoprene particles were subjected to the high pH value caused some doubt to be cast upon the generality of the conclusion of this experiment. Therefore, in order to eliminate the factor of slow diffusion into the neoprene particles the following experiment was performed. A precoagulated neoprene was prepared in the regular manner with Darvan, sodium hydroxide, and alum at a pH of 5.0 (no zinc oxide or antioxidant was used). This precoagulated neoprene was then divided into two parts—one part was adjusted to a pH of 8.0 by means of sodium hydroxide and held at this pH for 1 week; the other part at pH 5.0 was also stored for 1 week. The properties of handsheets prepared with these latices are shown in Table I and Fig. 1, from which it is evident that neoprene retention and effectiveness are considerably lower at a pH of 8.0 than at a pH of 5.0. The data at pH 5.0 fall on the curve of high neoprene effectiveness in Fig. 1, whereas the data obtained at pH 8.0 fall upon the curve illustrating poor effectiveness.

Two factors are worthy of consideration in these conditioning experiments:

It is known that alkalies promote cross linking of neoprene and the possibility suggests itself that cross linking may be taking place during the conditioning of the slurry at a pH of 8.0. Gel determinations made by benzene immersion of the polymer, after extraction of the alumina with dilute acid, indicate a greater degree of cross linking in the polymer after conditioning in an alkaline media for several days. However, this matter needs further study before definite conclusions can be made regarding the role of cross linking in the development of neoprene wet strength.

It is also well known that alumina changes in character under alkaline conditions, becoming both negatively charged and more dense. It is very likely that these changes in colloidal properties of the alumina account for the poorer retention and wet strength obtained under alkaline conditions.

In general, on the basis of the experiments performed, the particular method of precoagulation gives either good or poor wet-strength improvement—there appears to be no relationship between this improvement and the retention of the neoprene. Highest wet strength results when the alumina content is high and when conditions are neutral or acidic. Conditions of precipitation resulting in a tacky coagulated neoprene which agglomerates rapidly (as in the case of coagulation by sodium chloride) give good retention but poor strength properties. It appears possible that alumina may assist both retention and bonding between cellulose fibers and neoprene; therefore, it seemed important to determine the effect of the alum to neoprene ratio on these factors.

Alum to Neoprene Ratio

Using the precoagulation method as outlined in the experimental section, the amounts of sodium hydroxide were varied so that different amounts of alum were required for coagulation of the neoprene and for adjustment to pH 5.0. No zinc oxide was added. Thus, various amounts of alumina were present in the preflocculated neoprene. At the concentrations employed, it was impossible to coagulate the neoprene with alum alone at lower ratios than 0.1 gram of alum per gram of neoprene.

The data obtained with these various preflocculated neoprenes and alpha pulp are presented in Table II. The levels of retained neoprene varied between 1.2 and 2.2% (based on the fiber). The data for sodium chloride coagulation (taken from Table I) are included for purposes of comparison. It will be recalled that this precoagulated neoprene was prepared at an alum to neoprene ratio which was just sufficient to lower the pH to 5.0 (0.05 gram of alum per gram of neoprene). The actual coagulation of the neoprene latex was accomplished by the addition of sodium chloride.

Table II. The Effect of Alumina on the Neoprene Wet Strength of Alpha Pulp Handsheets

Alum used, g./g. neoprene	*Neoprene in sheet, %*	*Tensile strength, lb./in.*		
		Dry	*Wet*	*Wet/dry, %*
1.2	1.9	16.5	6.5	39
0.94	1.7	16.6	6.0	36
0.80[a]	1.5	15.8	5.1	32
0.66	1.4	17.0	5.2	31
0.61	1.3	16.8	5.1	30
0.40	1.9	15.7	5.8	37
0.20	1.3	15.1	5.0	33
0.10	2.2	16.0	3.3	21
0.05 (NaCl)	0.74	14.4	1.1	7.6
0.05	3.5	14.5	1.7	11.7

[a] Contains normal quantity of alum.
Note: No zinc oxide or antioxidant used.

The wet-strength data of Table II indicate a high effectiveness of the neoprene present in the sheet until the ratio of alum to neoprene is lowered to approximately 0.1; at this ratio, in spite of a somewhat higher quantity of neoprene in the sheet, the wet strength was significantly lower—i.e., 21 vs. 39% for the higher ratio. The sodium chloride-coagulated neoprene imparted practically no improvement in the wet strength.

Thus, it appears that not only the colloidal condition of the alumina but also the quantity of alumina associated with the neoprene has a bearing upon the wet strength obtained.

Removal of Alumina from the Sheet

The object of the next set of experiments was to learn more of the role of alumina. It appeared of interest to determine whether or not the alumina is important only in the process of incorporating neoprene properly into the sheet, or if its presence in the final dried sheet is essential. The results in Table III represent experiments in which two types of extraction were made. In the first series, preflocculated neoprene-alpha fiber suspension was treated with sulphuric acid at a pH of 2.5. The ash values in the table indicate that essentially all the added alumina was removed, since the ash value is near that of the alum-free control. The resulting handsheets exhibited only slight wet strength even though analysis of the sheets proved the presence of 2.5 parts of neoprene. Thus, the wet strength was only 1.5 pounds per inch in comparison with 5 to 6 pounds per inch usually observed for alpha pulp handsheets containing the same amount of neoprene.

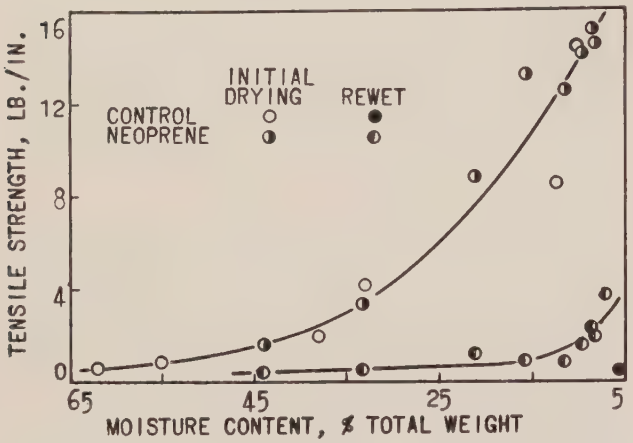

Fig. 2. Development of tensile strength during drying

In the second series, alpha handsheets were prepared using neoprene-alum prefloc which contained the normal quantity of alum used for coagulation. Some of the dried sheets were then leached with a dilute hydrochloric acid solution at a pH of 2.3 for 24 hours, blotted, soaked in dilute ammonium hydroxide solution for 1 hour, and dried between blotters. These handsheets were then tested for wet strength and compared with the non-leached sheets from the same preparation. The alumina content indicated by the ash value shows that most of the alumina had been removed by the acid extraction. The wet-strength values shown in Table III established the fact that wet-strength development was not impaired by the removal of most of the alumina. Hence, alumina appears important for the incorporation of neoprene by the preflocculation method of addition but it is not essential to the wet strength of the final sheet.

Table III. The Effect of Leaching Alumina from Neoprene-Pulp Suspensions and from Alpha Handsheets Containing Neoprene

	Neoprene, %	Ash content (Al_2O_3), %	Tensile strength, lb./in. Dry	Tensile strength, lb./in. Wet	Wet/dry, %
Neoprene floc-pulp	0	0.22	14.7	0.3	2
Mixture	2.5	0.27	14.5	1.5	10
Handsheets					
Before leaching	4.7	0.86	17.3	7.7	45
After leaching	4.7	0.26	15.4	7.7	50

Note: 15% neoprene added in all cases, 1.75% alumina (pulp basis) present in prefloc neoprene.

Table IV. The Effect of Drying upon the Development of Tensile Strength of Alpha Pulp Handsheets Made With and Without Neoprene

	Drying time, hr.	Moisture content, %	Tensile strength, lb./in. During drying	Tensile strength, lb./in. After rewetting
Control sheet	0	62.0	0.6	..
	0.5	55.0	0.9	..
	1.0	38.0	2.0	..
	2.0	33.0	4.2	..
	3.0	12.5	8.5	..
	4.0	10.3	14.4	..
	5.0	9.1	16.4	0.5
Neoprene sheet	2.0	44.0	1.6	0.4
	2.5	33.4	3.4	0.5
	3.0	21.3	8.8	1.2
	3.5	15.9	13.2	0.9
	4.0	11.7	12.5	0.9
	4.5	9.8	14.1	1.6
	5.0	8.4	14.5	2.0
	5.5	9.1	14.9	1.9
	6.0	8.8	15.1	2.3
	7.0	..	16.3	2.6
	15.0	..	16.0	3.4
	20.0	7.4	16.4	3.7
	40.0	..	16.3	4.4
	79.0	..	17.1	5.6
	98.0	..	17.6	6.8
	148.0	..	16.1	6.8

Note: Sheets were air dried at 50% R. H. and 73°F. between blotters.

RATE OF WET-STRENGTH DEVELOPMENT

The rate at which wet tensile strength develops in a sheet containing neoprene is of both practical and theoretical interest. The practical importance of the rate of development of wet strength has been adequately stressed in the work that has been done with melamine and urea formaldehyde resins in wet-strength papers. It appeared desirable to obtain similar data for neoprene. An examination of the variables affecting the rate was prompted by observation in our laboratories and by reports of one or two mill trials that full wet strength was not obtained immediately after normal drying, but that the wet strength continued to increase with further heating of the paper. Another matter of practical interest is the possibility of the development of wet web strength on the paper machine.

Wet Web Strength

In order to determine whether neoprene-containing sheets were stronger, during the drying process, than control sheets, a series of alpha handsheets were prepared and pressed at room temperature to approximately 65% water content. These sheets were then allowed to dry between blotters at room temperature (73°F. and 50% R. H.) and samples were taken peri-

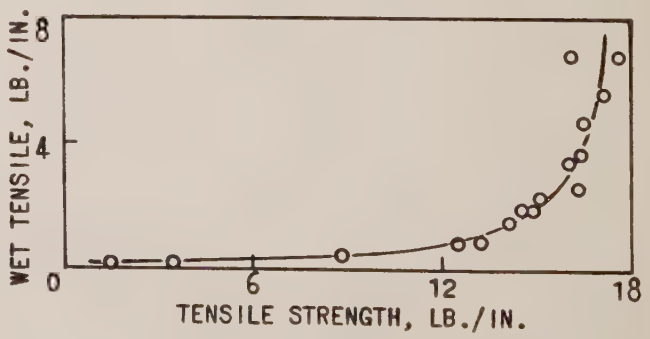

Fig. 3. Development of wet tensile with tensile strength

Table V. Development of Wet Tensile Strength of Neoprene-Containing Alpha Pulp Handsheets with Curing

Time of curing, min.	Wet tensile strength, lbs./in. Cured at 41°C. Observed	41°C. Reduced	68°C. Observed	68°C. Reduced	92°C. Observed	92°C. Reduced
0	3.1	0	3.0	0	2.8	0
5	..	..	3.6	0.6	5.5	2.7
10	..	..	..	..	6.8	4.0
15	4.1	1.0	5.9	2.9	7.0	4.2
25	..	..	7.1	4.1	..	..
30	4.9	1.8	..	..	7.7	4.9
45	..	..	7.1	4.1	..	..
60	5.5	2.4	..	..	8.2	5.4
85	..	..	7.8	4.8	..	..
90	..	..	..	..	8.6	5.8
120	6.1	3.0	8.2	5.2	9.3	6.5

Note: Neoprene content approximately 5%, moisture content of sheets approximately 6%.

odically for moisture determination and strength tests at that particular moisture content. The results of these tests, shown in Table IV, are plotted in the upper curve in Fig. 2. The points representing tensile strength vs. moisture content fall on a common curve, whether or not neoprene was present. Thus, within the limit of precision of these tests, no significant increase in tensile strength of the wet web is imparted by the approximately 5 parts of neoprene present in these sheets. It must be recognized, however, that tensile strength is only one of the factors which determines processibility of the wet web. Thus, these tests do not necessarily disagree with the improved running characteristics of neoprene-containing paper noted in some mill trials. One method of studying the development of wet strength during drying is to determine the wet strength of partially dried samples such as those discussed in the preceding paragraph. The values obtained in such a series of tests are shown in Table IV and the lower curve in Fig. 2. It is noted that no significant wet strength developed until these sheets (before rewetting) had dried to less than 15% moisture content.

It is apparent from the curves of Fig. 2 that, as the sheet dries, the tensile strength increases to a considerable fraction of the final value before the rewet tensile strength becomes significant. This relationship is shown directly in Fig. 3, based on the data in Table IV. The relatively abrupt rise in wet tensile strength is apparent.

The rate of development of wet strength, under these particular drying conditions, may be judged from the curve in Fig. 4, which presents a portion of the data in Table IV. The rate of development, which is proportional to the slope of the curve at the selected time, is low at the beginning when the moisture content of the specimens is high. The rate increases sharply and is maximum in the neighborhood of 4 hours with the

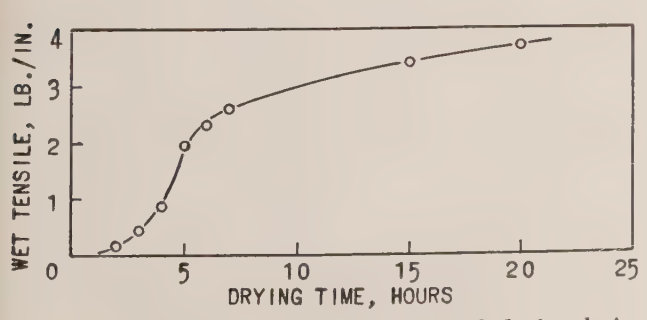

Fig. 4. Development of wet tensile strength during drying

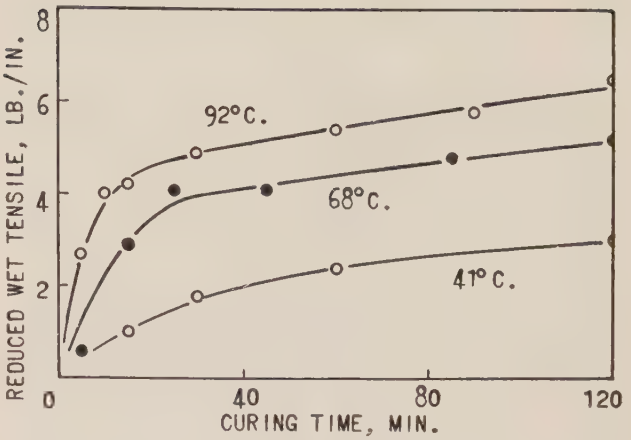

Fig. 5. Development of wet tensile strength with curing

moisture content of the order of 12%. The rate then decreases as drying proceeds.

It appears that the rate of development of wet strength under these conditions is strongly dependent upon the moisture content and the rate of removal of water. Capillary forces must draw fibers and fibrils into intimate contact and bonding must be well advanced before wet strength becomes significant.

It is also clear that an examination of the influence of "curing" conditions on the rate of development of wet strength is complicated by this behavior. A neoprene-treated sheet, dried at room temperature to a moisture content in the normal range, already possesses a considerable wet strength, and rate studies on dry sheets must be confined to the subsequent changes in wet strength. It was found that sheets could be dried quickly to average moisture content of the order of 6%, by use of elevated temperatures. Wet strengths of the order of 3 pounds per inch were obtained when the drying was carefully controlled. Sheets so dried were used for a study of the development of wet strength at three temperatures: 41, 68, and 92°C.

Alpha pulp handsheets containing approximately 5% neoprene were formed and pressed in the usual manner. The sheets were dried to approximately 6% moisture content on a steam-heated drum in a period of 2 minutes. The sheets were then individually sealed in preheated friction top cans with an appropriate amount of water (determined by trial) to maintain the moisture content during the subsequent curing periods. The cans were placed in ovens and, at intervals, a can was removed and opened without cooling and the sheet cut into strips which were immediately immersed in water. The wet tensile strengths are presented in Table V. The reduced wet tensile strengths observed after curing at 41, 68, and 92°C. for various lengths of time are shown in Fig. 5. The reduced strengths were obtained by subtracting the observed wet tensile strength at zero curing time from the observed values at other curing times. It will be noted that the early rates of wet tensile strength development increase with temperature in the manner reported for other wet-strength additives.

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A New Method of Detecting Slime in Pulp and Paper

STANLEY J. BUCKMAN and VIRGINIA HENINGTON

The preparation and use of a ninhydrin indicator solution for the detection of slime in pulp and paper is described. The test is based on the determination of protein which is always present in microorganisms and not generally present in uncoated paper.

In 1939, Rubin and Rubin (*3*) presented a well-illustrated article on spots and specks in paper. These authors concluded that spots and specks in paper generally can be traced to three sources; namely, microorganisms, foreign particles, and operating defects. As noted, experienced mill personnel frequently can recognize the type and origin of specks and spots encountered in pulp and paper by visual inspection and a few simple tests. However, the need for greater accuracy has resulted in the increasing use of microscopic examinations, determinations of fluorescence under filtered ultraviolet light, and chemical tests for pitch, starch, and different chemical elements, particularly metals.

Rubin and Rubin briefly outlined a procedure for a systematic routine laboratory analysis of spots and specks in paper. About 10 years later, Dalton and Wiltshire (*1*) elaborated on a similar general procedure and presented it in the form of a quite detailed key. However, this key still left the identification of slime spots on an indefinite basis with only the following final identifying characteristics determined by removing the spot from the sheet, staining with Hertzberg's stain, and examining under a microscope:

> "Some fibres, much fibre debris, clay, dirt and grit; may show filamentous growth or granular structure."
>
> "Few fibres, much fibre debris, clay, etc., may show filamentous growths."

Because of the need for a simple, rapid, specific test for microorganisms in spots and specks in pulp and paper and in deposits from pulp and paper machine systems, the authors initiated the study reported in this paper. Prior experience had shown that culturing "wet tails" from paper machine breaks provided helpful indications in some cases, but the results frequently were difficult to interpret. The use of various techniques, such as pressing the "tails" on the surface of the culture media and observing the growth pattern, did not yield more definite results. Moreover, the method was time consuming and is not applicable to "dry tails" or the examination of spots on paper which has passed through the driers with the resultant killing of most of the microorganisms present. Since repeated work with microscopic examinations of stained and unstained spots and deposits also seemed to lack the simplicity and reliability of a suitable test method for use in pulp and paper mills, emphasis was placed on chemical tests. The most logical approach in this direction seemed to be an evaluation of different tests for protein, a universal component of microorganisms and not present in detectable amounts in uncoated paper, such as newsprint and kraft. Tests of different reagents showed that ninhydrin, triketohydrindene hydrate, offered the best possibilities from the group of currently available indicators. Work thus was concentrated on this indicator. The test reagent which was developed is a modification of one described by Moore and Stein (*2*). It consists of a solution of ninhydrin buffered with sodium citrate. This reagent is very sensitive and yields a color within the range from red through violet to blue in the presence of proteins, peptones, peptides, and amino acids which contain a free carboxyl and an α-amino group. Ammonium salts, certain amines and amides also give a positive result when present in appreciable amounts. The reagent, identified as "Bulab Slime Indicator"; supplementary equipment; methods of use; and results obtained in testing spots and specks in pulp and paper and deposits from pulp and paper machine systems are described in the following:

Stanley J. Buckman, Member TAPPI; President, and Virginia Henington, Assistant Chemist, Buckman Laboratories, Inc., Memphis, Tenn.

MATERIALS AND EQUIPMENT

Bulab Slime Indicator

The indicator solution is prepared using sterile distilled water, chemically pure ingredients, and thoroughly clean, sterile glassware in a room with ammonia-free air as follows:

Solution A—Dissolve 0.14 gram of sodium hydroxide and 0.43 gram of citric acid in 49.00 gram of sterile distilled water.
Solution B—Dissolve 0.50 gram of ninhydrin (triketohydrindene hydrate) in 49.00 gram of methyl cellosolve.

Combine solutions A and B, add 0.57 gram of Activol DS (alkyl naphthalene sodium sulphonate) and shake thoroughly until the Activol DS dissolves. The stock supply of solution then can be stored in a dark colored bottle at room temperature for several months. A small amount of precipitate may form during storage but this does not reduce the effectiveness of the clear supernatant solution.

Beaker and Spatula

Any available spatula and beaker of convenient size can be employed after thorough cleaning.

Dropper Bottle and Tweezers

A thoroughly clean, dark colored bottle of about 1 oz. capacity, preferably equipped with a dropper in the cap, is a satisfactory container for the working supply of solution. Part of the stock supply of indicator should be transferred to a small bottle of this type to avoid possible contamination of the stock supply by repeated removal of solution from it with a dropper.

Any small pair of tweezers which have been thor-

oughly cleaned are satisfactory and are useful in straightening "break tails" and generally keeping contact of the paper with the human skin at a minimum, particularly on and around the suspected slime spot and the control spot, as described under "Methods."

Oven

Any suitable size electric oven operating at 90 to 105°C. is satisfactory. It is preferable to have an oven equipped with a glass inner door to permit observation of the progress of the development of color in the spots to which indicator was applied to the pulp or paper. The ovens generally in use in the pulp and paper industry for moisture content determinations of pulp and paper have been found satisfactory when the precautions described under "Methods" are observed.

METHODS

Care should be taken to avoid appreciable handling of the pulp and paper prior to testing, particularly if wet and specifically on or around the suspected slime spot and the area which will be used for the control spot as described in the following. The test is sensitive enough to detect protein deposited on the pulp or paper from the fingers.

Wet pulp sheets should be dried to a moisture content of 5 to 15% on a moisture-free basis before testing with the indicator solution. Deposits from pulp and paper systems can be smeared on a sheet of dry paper with a spatula and tested without drying. Such deposits should be collected in a thoroughly clean beaker and should not be touched with the hands during the collection procedure.

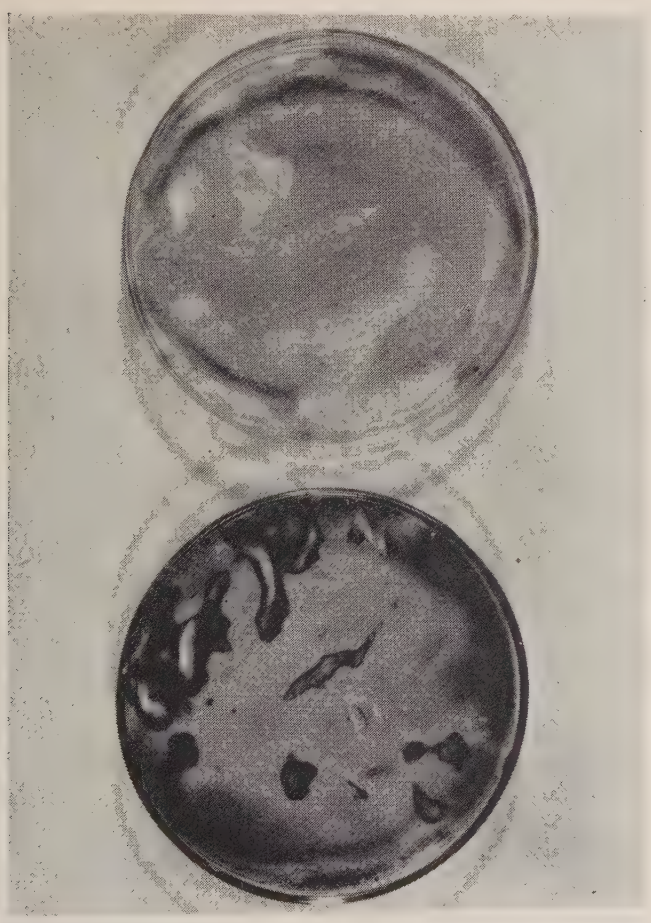

Fig. 1. Color produced by the reaction of Bulab Slime Indicator with the protein of slime from the wire pit of a fourdrinier machine making newsprint. (The Petri dish at the top shows the appearance of the slime without indicator while the one at the bottom shows the color resulting from reaction with the indicator)

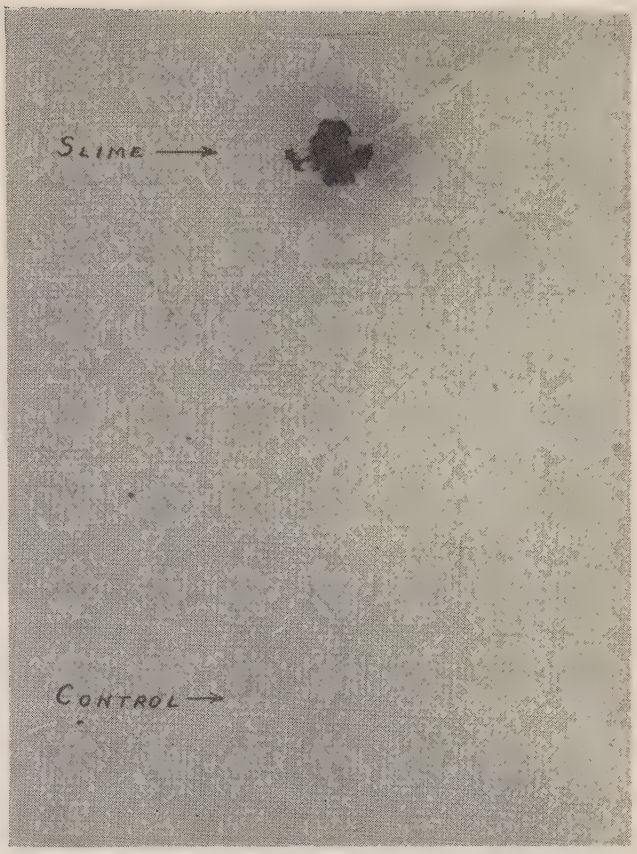

Fig. 2. Appearance of a control spot and a spot of slime from a sulphite pulp mill flat screen smeared on newsprint and tested with Bulab Slime Indicator

Place the piece of pulp or paper containing the suspected slime spot on a clean sheet of pulp or paper to avoid direct contact of the test piece with the working surface of the table or bench. Flatten the piece as necessary with the tweezers to provide a reasonably level surface to receive the indicator. Place 4 drops of the indicator on the center of the suspected slime spot or portion of the "tail" where the break is believed to have originated and 4 drops on a control area of the same sheet, preferably at least 2 inches from the suspected slime spot. Wait 10 minutes to allow the indicator to soak into the pulp or paper. Then transfer the paper to an oven and heat for 2 to 10 minutes at 90 to 105°C. Observations should be made during the heating period and the piece of pulp or paper removed from the oven at the first evidence of development of color in the control spot. Proper control of heating is important. It is better to underheat than overheat. Overheating will result in the development of too much color in the control spot. When the oven is not equipped with a glass inner door, the door should be opened at the end of 2 minutes and at 1 minute intervals thereafter with heating being extended as necessary to compensate for the lower temperature resulting from opening the oven door. When the temperature gradient between the bottom and top shelves is pronounced, placing a clean sheet of pulp or paper below test pieces on the bottom shelf will usually protect against overheating.

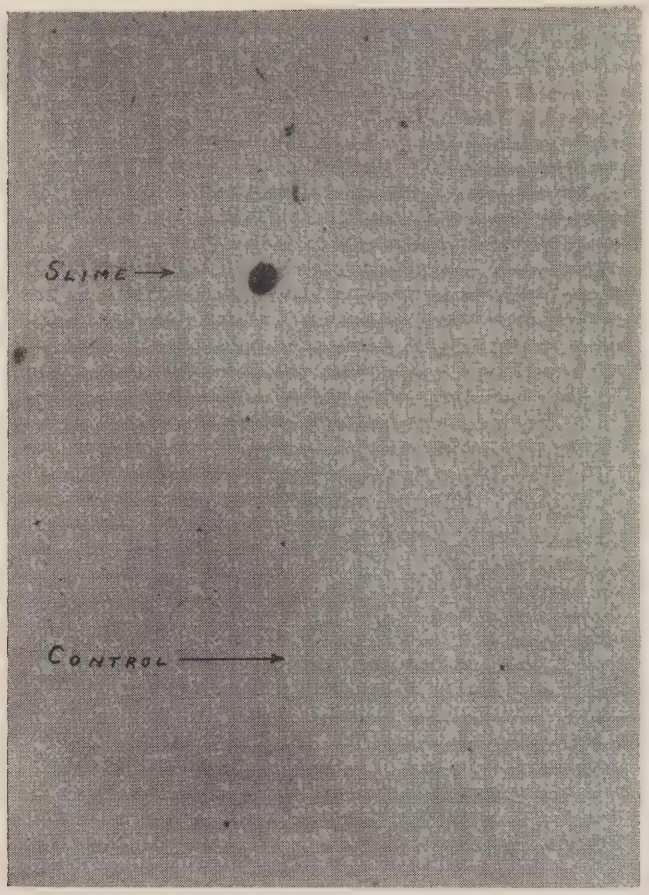

Fig. 3. Appearance of a control spot and a spot of slime from a pulp screen box which was mixed with the pulp before the handsheet was made and subsequently tested with Bulab Slime Indicator

The development of a color within the range from red through violet to blue in and around the suspected slime spot is a positive result and indicates the presence of slime if the color is markedly darker than that obtained on the control spot. The color may be confined to the slime spot or it may extend out from the slime spot proper for a variable distance as the result of diffusion of the proteins from the spot into the surrounding paper. The control spot frequently will exhibit some color. However, if there is a pronounced difference in shade of color between the suspected slime spot and the control, the presence of slime still is indicated. When the suspected slime spot is dark in color prior to the application of the indicator, examination of the opposite side of the sheet may provide a better appraisal of the indicator reaction. The use of transmitted rather than reflected light also frequently is helpful in evaluating the result obtained.

The difference in color between slime spots which have given a positive test and control spots will gradually decrease with storage. With increasing age, there usually is some increase in shade of color in the control spot and some fading of the color of the slime spot. Storage of "break tails" or pulp or paper with spots for future comparisons after a period of several weeks thus is not recommended.

RESULTS

Figure 1 shows two Petri dishes containing slime from the wire pit of a fourdrinier machine making newsprint. The dish at the top illustrates the appearance of the slime without any indicator and the one at the bottom shows the same slime to which drops of the indicator had been added at various places in the dish. Both dishes were heated in the oven for the same time at a temperature between 90 and 105°C. The dish at the bottom shows the typical reaction obtained between the indicator and the protein of the microorganisms in the slime which yields a violet to blue color while the dish at the top exhibits the normal whitish gray color of the particular slime.

The photograph in Fig. 2 shows near the top a deposit from a sulphite pulp mill which was smeared while wet on a sheet of newprint and tested with the indicator. A positive reaction was obtained for the deposit with a violet color appearing in the slime comprising the spot and a zone around it as the result of the diffusion of proteins from the wet slime into the surrounding paper. In contrast, the control spot in the bottom portion of the photograph shows essentially no color.

Figure 3 illustrates a handsheet of unbleached kraft which had pieces of slime from a pulp screen box mixed with the pulp before the sheet was formed. A positive result was obtained for a slime spot located in the top portion of the sheet when tested with the indicator with a negative result for a control area located in the bottom portion of the sheet which was heated under the same conditions after the application of the same amount of indicator.

The paperboard in Fig. 4 shows the character of posi-

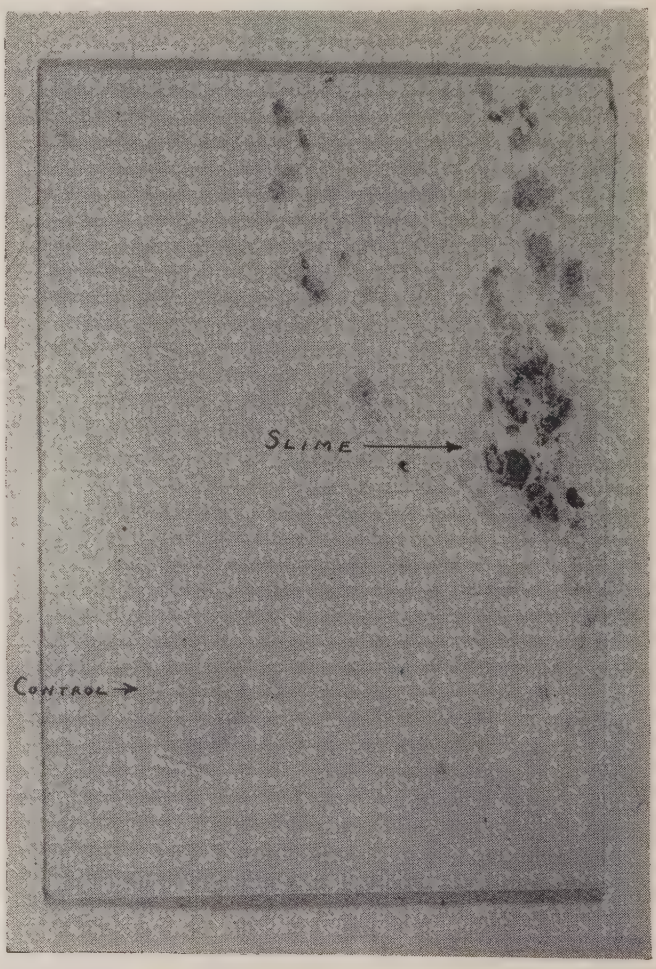

Fig. 4. Appearance of a control spot and spots of pink slime on paperboard when tested with Bulab Slime Indicator

tive reaction obtained for spots of pink slime when tested with the indicator. A very light violet color was obtained in the control spot in the lower left-hand corner but an adequate difference in amount of color was obtained between the suspected slime spot and the control spot to justify a conclusion that the spots definitely were caused by slime.

Figures 5 and 6 show "break tails" which gave positive reactions for suspected slime spots that caused the breaks and negative results for control spots located below the slime spots on the same pieces of paper and tested with the indicator under the same conditions. The "break tail" shown in Fig. 5 is newsprint, and the one shown in Fig. 6 is 9-point corrugating medium composed predominantly of semichemical hardwood pulp.

The results presented and those obtained from cooperative work in a number of paper mills show that Bulab slime indicator is a helpful tool in determining whether or not breaks and spots in paper and spots in pulp are caused by slime. It has been found equally effective in testing deposits from pulp and paper machine systems to determine whether a significant microorganism component is present in such deposits, and it seems probable that it will have fields of usefulness for similar applications in other industries. Information about the indicator and a description of the method of use is presented at this time so that it will be available for others to employ in further exploring the complete range of usefulness of the indicator as well as its limitations. Tests have indicated that the presence of ammonium compounds to the extent used in chloramines does not limit the use of the indicator by causing too much color to develop in control spots. However, this subject needs further exploration before final conclusions can be made. The use of animal glue and other proteins in some paper furnishes and in conjunction with the operation of savealls are all factors which need to be considered further. Indications are that careful comparisons of color intensities for suspected slime spots and deposits with control spots may make it possible to obtain useful information about the presence of slime even in the presence of small amounts of ammonium compounds, amino acids, and protein from other sources. In the meantime, the indicator is available for use on the many applications where interfering substances are not present in significant amounts.

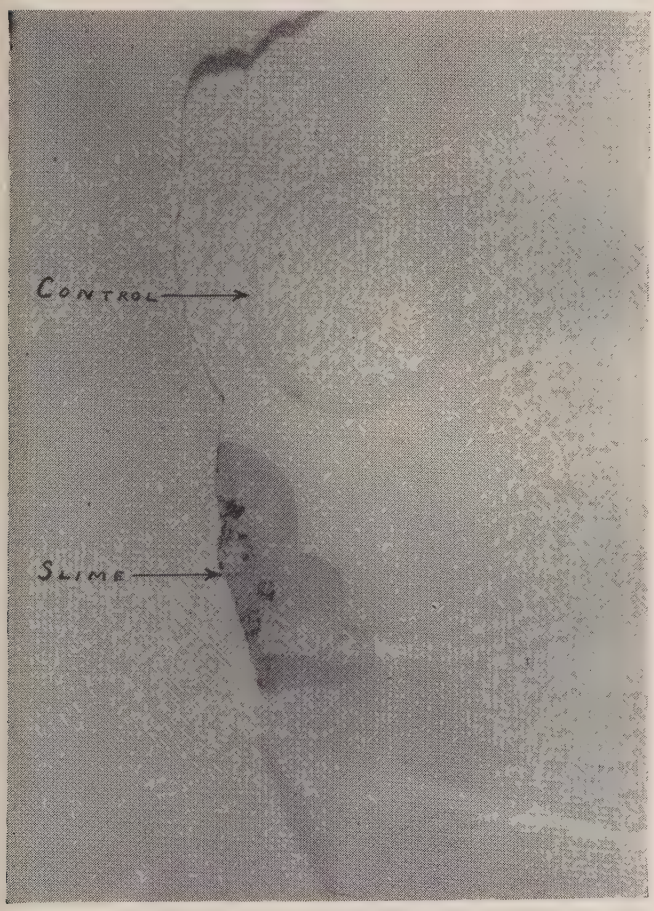

Fig. 5. Appearance of a control spot and slime spots on a newsprint "break tail" when tested with Bulab Slime Indicator

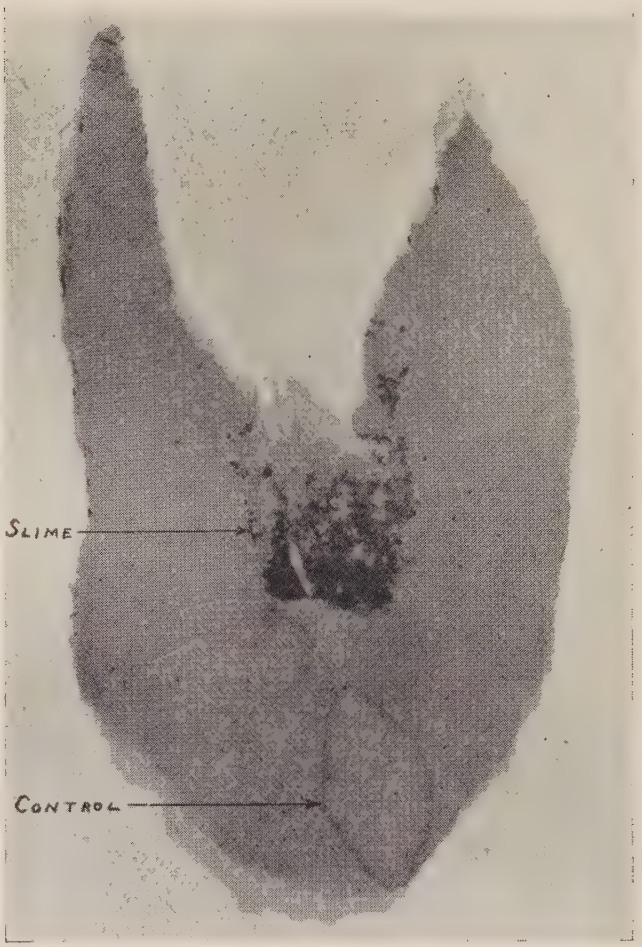

Fig. 6. Appearance of a control spot and slime spots on a "break tail" of 9-point corrugating medium when treated with Bulab Slime Indicator

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Acknowledgment is made to many friends in the pulp and paper industry for their help during the development of Bulab Slime Indicator. Their expressed need stimulated the work. They rendered assistance essential to the success of the project by providing slime samples, "break tails," and spotted paper samples and by providing comments based on their use of the indicator in the mills.

An Optical Projection Method for Measuring Fiber Length

THOMAS FYFE

Several articles have been published on the value of fiber length measurements and on various methods for measuring fiber length, but there is still much need for a method, specifically designed, for the routine measuring of fiber length on a laboratory scale. An optical projection method is described in this paper that is used daily for the routine measuring of fiber length in pulp and nonsized paper. The method and apparatus are described in sufficient detail to permit easy adoption by anyone in need of a method. Most of the steps in the method are used or well known by present-day fiber analysts. Statistical data are included to show the reproducibility of the method, and various types of graphs are also included to illustrate a number of ways that results may be reported.

THE pulp and paper industry at the present time generally recognize two basically different types of test procedures for obtaining an estimate of a so-called "average fiber length" of a given sample. They are usually referred to as optical and mechanical tests. The optical method consists of making a suspension of fibers in water, preparing a slide from this suspension, and by means of an optical device (microscope or microprojector) making an actual count of the number of fibers that fall within certain length (or width) groups. The mechanical method also requires a suspension of fibers in water. They are then segregated into several length categories by means of a mechanical classification device. The flow pattern, agitation, etc., are somewhat different from one classifier to another, but the basic feature is a series of screens of graduated openings through which the fiber suspension passes.

Different authors (*1, 2, 3, 5*) who have made studies of the application of fiber length data have presented widely varying opinions on the relative merits of the different fiber length procedures. One author (*3, 4*) suggests that the only meaningful fiber length result is one obtained by a combination of the mechanical and optical methods. It is generally agreed, however, that the time required to complete an individual test has been the most important factor in preventing a wider application of fiber length analysis as a stock preparation control.

For several years the writer has used an optical projection method for measuring the length of fibers in pulp shipments. A modified B & L microprojector (Fig. 1) is used to project an image of the fibers onto a screen. The standard lens system and stage of the microprojector have been replaced with a 16-mm. 10 × B & L objective and a much larger stage to accommodate the mechanical stage that is attached. The microprojector and transformer are mounted together on a wooden base to form a single and compact unit. The screen is mounted 28 inches from the microprojector and has a calibrated scale of concentric circles in 0.5-mm. divisions (Fig. 2). The center or smallest circle of this scale is subdivided into 0.10-mm. divisions by means of dots that radiate from the center of the circle in eight equally spaced spokes. A wooden box with black inside walls and closed on all sides but the viewing end contains the microprojector and measuring screen in fixed positions. The magnification at the screen is 50×. The field of view is 7 mm. in diameter which permits the measuring of extremely long fibers without having to fix reference points along the fibers. The shortest fiber considered is 0.10 mm. long and a fiber length frequency chart is prepared with 0.10-mm. groups (Fig. 3). The most common parameter used to characterize the resulting data is the so-called average fiber length which is obtained by dividing the total length of all the fibers measured by the total number.

A statistical study was made to evaluate some of the possible sources of variability involved in this method and to work out if possible a better way to graphically describe the results of a fiber length determination to the man in the mill.

PROCEDURE

The steps involved in this optical projection method for measuring fiber length are as follows:

1. The selection of a sample of proper size and condition.
2. The selection of a portion of this sample for the actual fiber length determination.

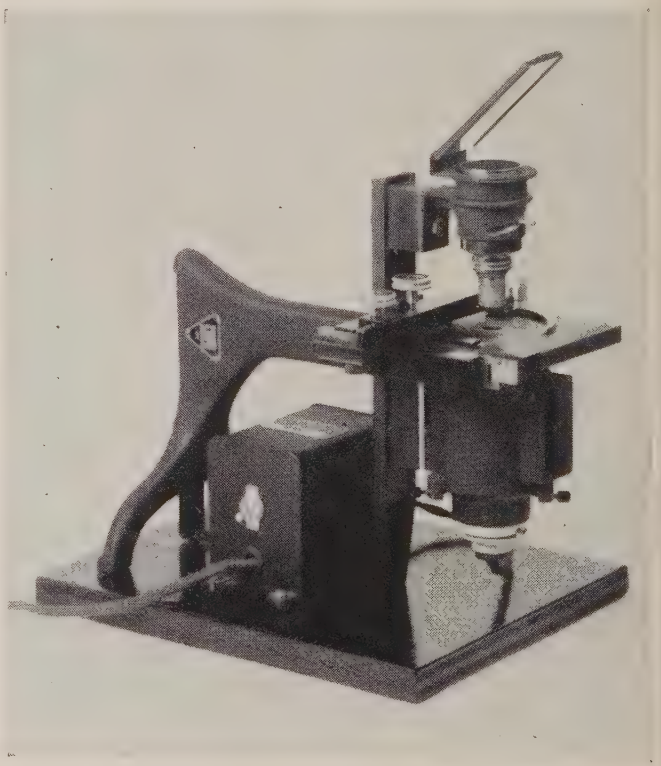

Fig. 1

THOMAS FYFE, Eastman Kodak Co., Kodak Park Works, Rochester, N. Y.

3. The defibering of this smaller portion.
4. Staining and straightening of the fibers.
5. The measuring of the fiber length.
6. The recording of the fiber length data.
7. The calculation of the total fiber length and the cumulative percentages.

The Selection of a Valid Sample

Select a piece of paper or pulp lap about 6 inches square that as nearly as possible represents the pulp or paper lot to be tested. Make sure that the sample has not been handled in a rough way or subjected to scuffing or rubbing on a dirty surface.

The Selection of a Smaller Portion from this Sample

Select an area of approximately 1 inch square from a location in the middle of the sample. Wet the entire sheet thoroughly and by using the thumb push out an area approximately equal to 1 square inch. Wetting of the sample swells and loosens the matted fibers and makes it possible to remove a portion of the sample

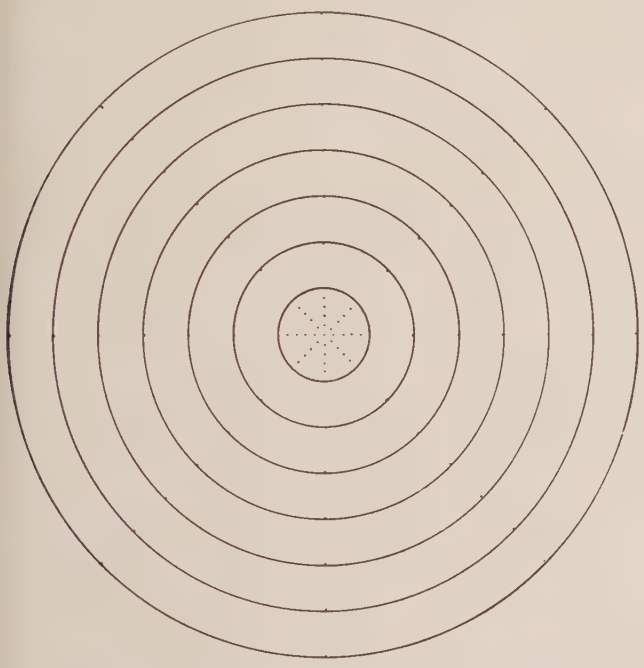

Fig. 2. Measuring scale on projection screen

without breaking the fibers. Do not take a sample from a cut or dry torn edge.

Defibering

Place the small 1-inch square in a 400-ml., flask containing approximately 350 ml., of distilled water. Allow the sample to soak for 5 minutes and then shake the flask back and forth to defiber the sample. Do not use glass beads and do not shake the flask too vigorously or fibers may be torn or broken. Immediately after shaking and while the fibers are still completely dispersed, decant off approximately one third of the slurry and replace this with an equal volume of distilled water. Repeat this shaking and diluting process until the slurry contains approximately 75 fibers per drop.

Staining and Straightening of the Fibers

Transfer 3 drops of thoroughly dispersed slurry to a clean microscope slide. Use a 7-inch length of 4-mm. glass tubing fitted with a rubber dropping bulb for transferring the slurry to the slide. Confine the slurry

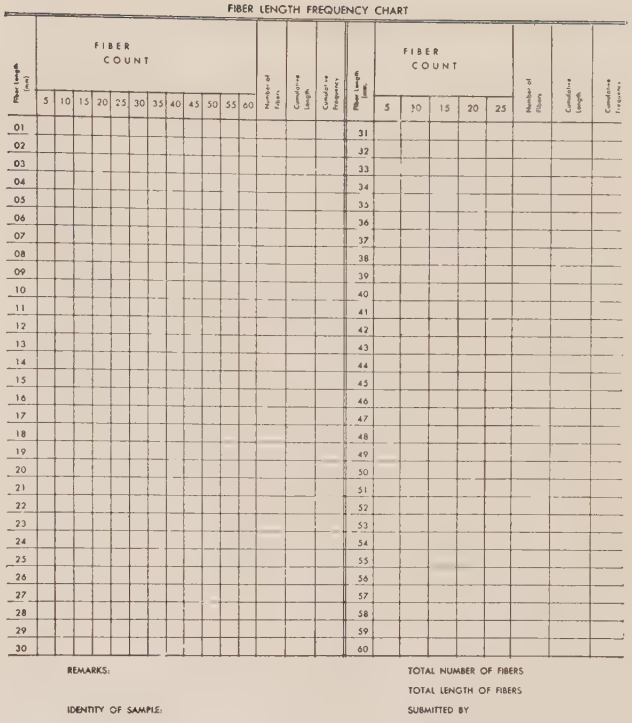

Fig. 3

to as small an area of the slide as possible. Allow the water to evaporate from the surface of the slide by heating on a hot plate held at 50 to 60°C. Tap the slide occasionally during the drying process to prevent the fibers from bunching together. Do not allow the fibers to heat after going to dryness. Place 2 drops of Herzberg stain on the fibers and allow the fibers to take up the stain for 1 minute. Under a Greenough-type microscope at 10× magnification, straighten and align the fibers side by side by means of a dissecting needle in an unused area of the slide. Place a cover-glass over the straightened and aligned fibers and irrigate them

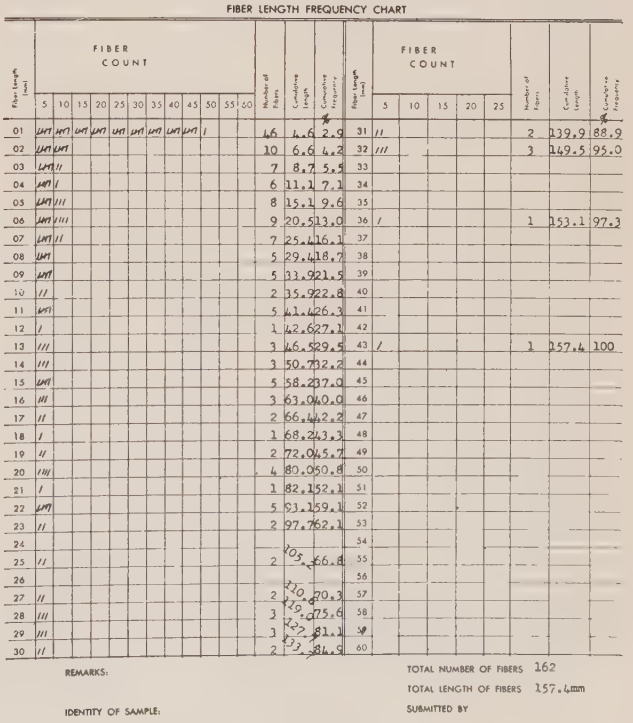

Fig. 4

Table I. Sample A—Tabulation of Results from Individual Slides

		Sample 1	2	3	4	5
20%	Operator I					
	a	0.73	0.92	0.62	0.37	0.45
	b	0.53	0.57	0.67	0.70	0.50
	Operator II					
	a	0.82	0.92	0.74	0.62	0.67
	b	0.80	0.73	0.60	0.78	0.65
50%	Operator I					
	a	2.14	2.48	1.84	1.77	2.32
	b	2.10	2.15	2.47	2.21	2.23
	Operator II					
	a	2.31	2.52	2.13	2.62	2.10
	b	2.65	2.53	2.12	2.23	2.25
80%	Operator I					
	a	3.29	3.50	2.80	2.96	3.42
	b	3.16	3.14	3.19	3.30	3.50
	Operator II					
	a	3.42	3.23	3.02	3.36	3.21
	b	3.78	3.56	3.06	3.48	3.15

with a drop of Herzberg stain. Also place a cover-glass over the short fiber fragments that have been left in the original 2 drops of Herzberg stain.

The Measuring of the Fiber Length

Check the scale on the measuring screen to make sure that the divisions coincide with the 0.10-mm. divisions on the micrometer object slip. Adjust the projection distance of the microprojector, if necessary, to make both scales coincident. Place the prepared slide of straightened fibers on the stage of the microprojector and project the image of the fibers onto the screen. Start at the near right-hand corner of the cover-glass and measure all the fibers that come into view as the slide is traversed from right to left. Move the slide backward about 6 mm., or until a new field of fibers come into view, by means of the mechanical stage, and again measure all the fibers as the slide is traversed from left to right. Continue in this manner over the area covered by the cover-glass until all of the fibers are measured. Repeat this same searching and measuring operation within the area containing the short fiber fragments. Do not measure fiber fragments less than 0.10 mm. in length and do not measure fibers that are not of the same nature or identity as the test sample. Also disregard any fibers that appear out of focus as in most instances these will be located on top of the cover-glass or on the underside of the slide. Fibers that are

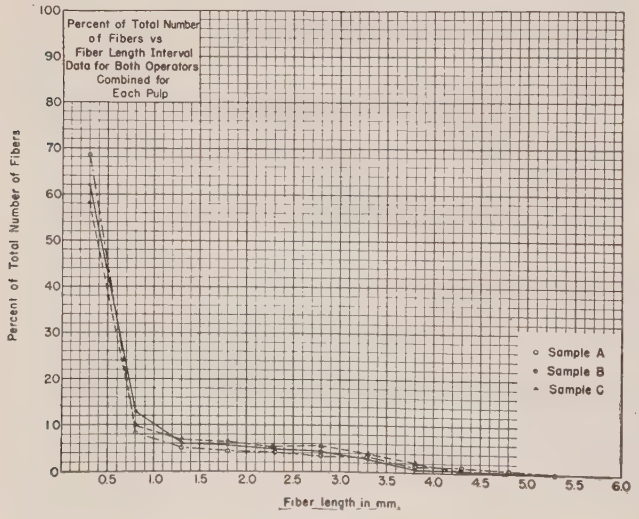
Percent of Total Number of Fibers vs Fiber Length Interval Data for Both Operators Combined for Each Pulp
Percent of Total Number of Fibers
Fiber length in mm.
Sample A
Sample B
Sample C

Fig. 5

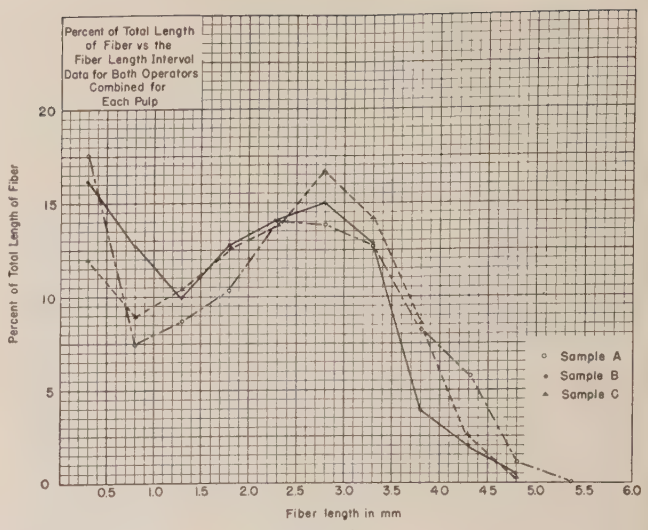
Percent of Total Length of Fiber vs the Fiber Length Interval Data for Both Operators Combined for Each Pulp
Percent of Total Length of Fiber
Fiber length in mm
Sample A
Sample B
Sample C

Fig. 6

bent or twisted should be measured in steps by fixing reference points along their length. Add the lengths of all the steps to obtain the total length of the fiber.

The Recording of the Fiber Length Data

Record the lengths of all fibers, both long and short, as they are measured on a fiber length frequency chart (Fig. 3).

STATISTICAL STUDY OF METHOD

It was the primary aim of this study to answer the following points concerning the reproducibility of the fiber analysis procedure:

1. What variability can be expected among replicate slides from one dispersion?
2. What variability can be expected among samples (different laps) of a single pulp bale?
3. What variability can be expected when different operators perform the fiber analysis?
4. How do the actual differences among the more common pulp grades compare with reproducibility of the test procedure?

An outline of the experimental procedure is given below:

Pulp 1

Sample 1		Sample 2		Sample 3		Sample 4		Sample 5	
OpA	OpB	OpA	OpB	OpA	OpB	OpA	OpB	OpA	OpB
—	—	—	—	—	—	—	—	—	—

This test cycle was reported for three pulps.

Table II. Sample B—Tabulation of Results from Individual Slides

		Sample 1	2	3	4	5
20%	Operator I					
	a	0.36	0.67	0.61	0.54	0.48
	b	0.34	0.68	1.02	0.85	0.61
	Operator II					
	a	0.51	0.62	0.90	0.97	0.62
	b	0.62	0.63	0.70	0.77	0.71
50%	Operator I					
	a	1.58	2.36	1.77	1.54	1.59
	b	1.58	2.10	2.46	2.42	2.03
	Operator II					
	a	1.53	2.02	2.32	2.13	1.85
	b	1.74	2.02	1.89	2.14	2.27
80%	Operator I					
	a	2.84	3.17	2.83	2.87	2.95
	b	2.65	2.80	3.30	3.06	2.81
	Operator II					
	a	2.80	3.03	3.20	2.88	3.10
	b	2.75	3.14	3.04	3.08	3.00

Thus, five samples representing different laps were taken from each of three bales, identified as A, B, and C. The bales from which the samples were chosen were so-called standard bales that are used as comparisons.

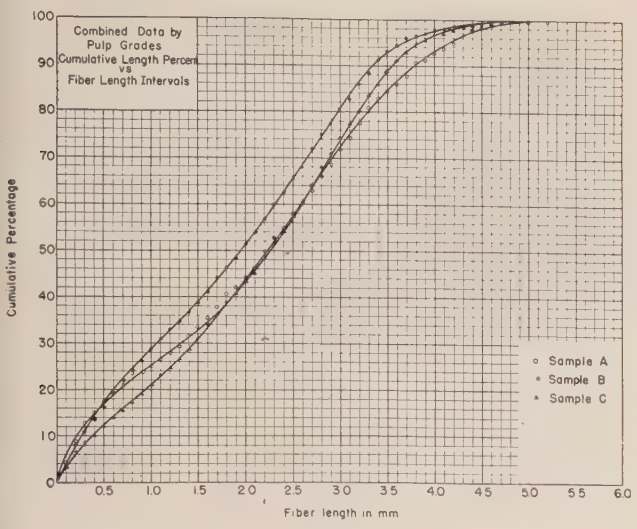

Fig. 7

Two operators were involved in the study and each operator made one dispersion from each sample. The operator next made two slides from each of his own dispersions and ran a fiber count of the various lengths on each slide.

Results and Discussion

Figure 4 is a typical example of the data obtained from a single slide. It is a frequency diagram of the number of fibers the length of which falls within the different 0.1-mm. intervals. It should be noted that no fiber less than 0.10 mm. in length is considered. As was mentioned previously, these data could be presented graphically in alternate ways, three of which were considered:

A. Per cent of total number of fibers vs. intervals of length.
B. Per cent of total length of fibers vs. intervals of length.
C. Cumulative per cent of total length vs. intervals of length.

The three forms are illustrated in Figs. 5, 6, and 7, where the combined data (all samples—both operators) for each pulp were plotted for each method.

Table III. Sample C—Tabulation of Results from Individual Slides

		Sample 1	2	3	4	5
20%	Operator I					
	a	1.00	0.69	0.64	0.81	0.62
	b	0.87	0.88	1.09	0.58	0.50
	Operator II					
	a	1.02	0.89	1.09	1.08	1.09
	b	1.00	0.85	1.37	1.04	0.89
50%	Operator I					
	a	2.47	1.67	1.82	2.26	1.88
	b	2.43	2.16	2.42	2.02	2.42
	Operator II					
	a	2.49	1.93	2.54	2.50	2.28
	b	1.98	2.20	2.38	2.33	1.97
80%	Operator I					
	a	3.30	2.98	3.00	2.98	3.36
	b	3.25	3.07	3.26	3.03	3.44
	Operator II					
	a	3.32	2.98	3.17	3.52	3.12
	b	2.83	3.08	3.40	3.22	2.78

Figure 5 is the percentage of total number of fibers vs. intervals of length. The data were grouped in 0.5-mm. intervals in order to smooth out the curve. Thus the first point plotted for pulp sample A was 68.5%—this means that 68.5% of all fibers counted had lengths between 0.1 mm. and 0.5 mm. (the actual point was plotted at 0.3 mm. which was the mid-point of the 0.1 to 0.5 mm. group).

A similar system was used for Fig. 6 except that percentage of total length found at each interval instead of percentage of total number was calculated. The results were obtained by multiplying the interval length by the number of counted fibers, summing to obtain the total length of fiber, and finally expressing the length at each interval as a percentage of the total.

Figure 7 is the same data expressed in a cumulative form. For example, the result plotted at 0.1 mm. is the percentage of the total length of fiber which was 0.1 mm. long. At 0.2 mm. the point represents the sum of both the 0.1 and 0.2 mm.; at 0.3 mm. the sum of 0.1, 0.2, and 0.3 mm., etc.

It is readily apparent that Fig. 5 (number of fibers vs. length) does not offer a satisfactory means of differentiating between the three pulps. Figure 6 is better in this respect but it is believed that the cumulative type curve in Fig. 7 is the best. Changes in the slope of the curve and/or a general shift along the horizontal axis can be easily noted and interpreted. It is also simple to determine the percentage of the total length of fiber that falls within arbitrary length intervals, and the curve can be fairly well characterized numerically by reading the 20, 50, and 80% points.

This latter feature of the cumulative curve was used to evaluate the reproducibility of the procedure. A curve was plotted from the data obtained on each slide run in the experiment. The 20, 50, and 80% points were read, tabulated, and evaluated by a series of variance analyses (see Tables I, II, and III). Their purpose was to determine (1) the reproducibility of replicate slides from one dispersion and (2) the significance

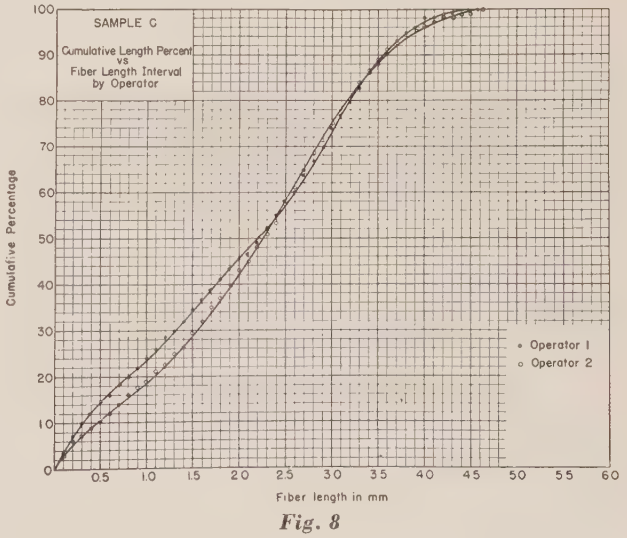

Fig. 8

and magnitude of sample to sample and operator to operator variability at each of the three different portions of the curve.

The following general conclusions could be made from this series of variance analyses:

1. Only one sample on one pulp was found to be significantly different from the others in its group. The difference was also of a relatively small order of magnitude (0.2 mm). There was not, then, any decisive evidence in this experiment that significant sample-to-sample (lap-to-lap) differences existed within pulp bales.

2. There were found to be real differences between operators at the short fiber fraction (20% points). Figures 8, 9, and 10 were plotted to show this effect. Each curve represents the combined results (five samples each in duplicate) by a particular operator for each pulp. It will be noted that the curves differ in the lower portions and gradually approach each other at the 50% points (Figs. 8 and 10 in particular). This indicates that one operator was not measuring the short fibers in the same manner as the second operator. However, a more recent study to determine the reason for the observed differences indicates that such variability can be reduced to where it will no longer be a significant factor.

3. Reproducibility of the average of duplicate slides at the different points 20, 50, and 80% along the cumulative curve was found to be as follows:

Two Standard Deviation Limits

	A	*B*	*C*	*Ave.*
20% point	±0.18 mm.	±0.20 mm.	±0.21 mm.	±0.20 mm.
50% point	0.31	0.43	0.38	0.38
80% point	0.25	0.22	0.24	0.24

These results represent the 95% (two standard deviation) reliability as it is obtained by the control procedure which is in current use. (It does not include operator variability for the reason given in (2) above.) This would mean, for example, that if a 50% point of 1.20 was obtained on sample B this result would be duplicated within ±0.43 (or from 0.77 to 1.63 mm.) about 95% of the time.

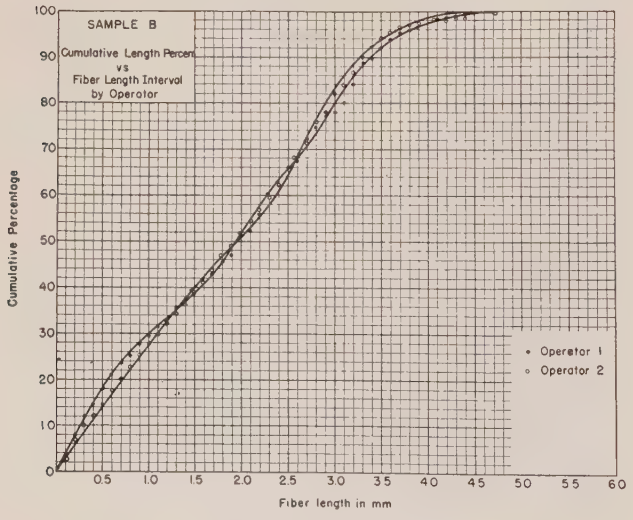

Fig. 9

The fourth aim of the study was to obtain a reliable curve for each of the three standard bales now in use for samples A, B, C. Figure 7 which was discussed previously is the plot of the combined data for each pulp. Twenty slides (five samples, two operators, duplicate slides) are included in each curve and they should represent a reliable picture of the fiber distribution in the so-called standard bales. It is obvious that there is not a great deal of difference between the three types of pulps. Considering the reproducibility data

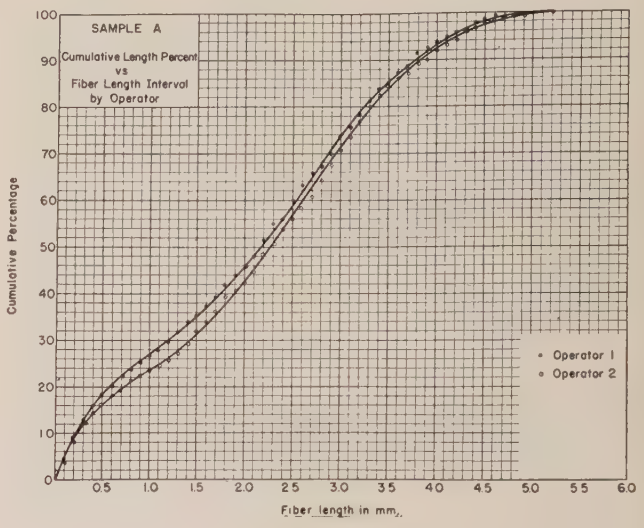

Fig. 10

presented previously it would be extremely difficult to differentiate between these three types of pulp if the procedure of two slides per sample were followed. By the same reasoning such a procedure is not sufficiently reproducible to differentiate between runs of the same pulp unless unusual differences were encountered or an unreasonable number of slides run.

CONCLUSIONS

A minimum of 400 fibers (two slides) must be measured in order to get a fiber length distribution which would be reproducible within ±0.40 mm. (50% point).

There was very little variability in fiber distribution among laps within a bale.

There was found to be a difference between operators in the measurement of short fibers; 0.1 to 0.5 mm. in length. More recent work indicates that this source of variability can be eliminated.

Composite curves representing all the data (20 slides on each of the three pulps) were very similar. The difference between pulp samples A, B, and C were so small that a single analysis (400 fibers) on each would not reliably differentiate between the samples.

Elaborate testing would be required of this or any other method to accurately characterize the fiber length distribution within a given sample, bale, or run of pulp. This amount of testing would be prohibitive. However, the fiber length data from the various tests could be combined into a composite cumulative curve which could be used to compare the entire run with previous runs, or with a standard comparison bale of the same type of pulp.

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The Sources of Wood Dirt in Unbleached Pulp

CARTER A. WATSON

The wood dirt in unbleached sulphite pulp varies in character and quantity depending on the wood supply and its method of preparation for pulping. Reduction of wood dirt, a necessary function in the pulping process, is accomplished by various methods. In choosing a method for more effective dirt reduction, information correlating the wood dirt with the dirt content of the final product is of considerable importance. This paper describes a method whereby information on this relationship can be obtained by small-scale experiments. The method is described and typical data with examples of their application to practical dirt reduction problems are presented.

SINCE cleanliness is one of the most important factors in the quality of unbleached sulphite pulp, the manufacturer is constantly faced with the problem of maintaining the dirt content of his pulp at an acceptable level. As is well known, most of the dirt in unbleached pulp originates from the bark, knots, stain, and rot in the wood, and because wood is a natural material of varying quality, the type and amount of dirt introduced into the pulp continually vary. Eliminating the dirt in the most economical manner to attain the production of uniform quality pulp is a major problem of the industry. The methods normally used to accomplish this dirt reduction are: (1) by wood selection, i.e., sorting and selecting the wood entering the sawmill; (2) by wood cleaning in the sawmill, i.e., culling out the rot or other types of wood dirt; (3) by dirt removal equipment in the pulp process line, such as rifflers, fine screens, and centrifugal classifiers. When considering a means of cleaning, usually more than one of these different methods will serve satisfactorily. However, all of these systems are costly and to arrive at the economic advantage of one over another factual knowledge about the type and amount of dirt to be removed is often required. It was therefore the purpose of this work to relate the quantity and character of wood dirt found in unbleached pulp to the specific sources of dirt in the wood.

An approach which would provide this basic information seemed to present itself in the pulping of separated fractions of wood dirt and the subsequent evaluation of the quantity and type of dirt in the pulp produced from these various sources of wood dirt. If such an analysis were made on a quantitative basis, it would seem that one could compare: (1) the different sources of wood supply with one another; (2) the wood cleaning required for the different wood supplies; (3) the costs entailed in wood selection and cleaning with the expense of additional dirt removing equipment in the pulp processing line. Considering the value of such comparisons, an attempt to gather additional data on this basis seemed well justified, and an investigation of this mode of analysis was undertaken.

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METHOD

The experimental procedure consists of: (1) sampling and classifying the wood chips; (2) pulping the chips and preparing pulp handsheets; (3) estimating the dirt content of the pulp.

The method of sampling the wood was chosen so that the specimen would adequately represent the supply being tested. This purpose was accomplished by withdrawing small samples from the chipper discharge over an extended period of time. More specifically, samples consisting of approximately 50 grams of chips were drawn every 10 seconds for a period of 1 hour. This quantity of chips represented a supply of about 100 logs or 300 sawmill slabs. The collected chips were then screened in the laboratory (*1*) to remove sawdust and oversized chips. Next, the chips containing dirt were separated from the clean chips and then sorted into the following fractions: (1) chips containing any part of a knot; (2) chips containing any outer bark; (3) chips containing stain from the cambium region; (4) chips containing pitch pockets; (5) chips containing rot; (6) chips with worm or insect holes.

The chip samples containing defects were then pulped according to the following procedure:

Each fraction was placed in an individual bag of stainless steel screen and all the bags loaded into a stainless steel cooking basket which was then suspended in a commercial plant digester at a level 24 feet from the top. Pulping was carried out under standard conditions prevailing in the mill (*2*). After the digester was blown, the basket was removed and immediately quenched in cold water. The chips from each container were washed separately to remove dissolved lignin and foreign particles of dirt. Particular care was taken to avoid any disintegration of the chips at this time.

After completion of this washing each fraction of the dirty chips was diluted with a known amount of pulp produced from the previously separated clean chips. This dilution was necessary because it became evident that the dirt concentration of the segregated samples was so high that an accurate dirt count was impossible on handsheets prepared from them. The proportion of clean chips added ranged from 50 to 99% depending on the type of dirt under investigation. The final concentration to use was determined by inspection of trial handsheets.

After dilution with clean pulp, the chips were disintegrated, washed, and screened in a manner duplicating as closely as possible the commercial process. Disintegration was accomplished in two steps: first, breaking up the chips by hand; and second, adding sufficient water to bring the consistency to 3%, and then stirring with a Lightnin mixer (Model CV 4) to simulate the agitation occurring in the blow pits, pumps, and storage chests. This pulp was then put through a laboratory flat screen equipped with a type-E chromium plated

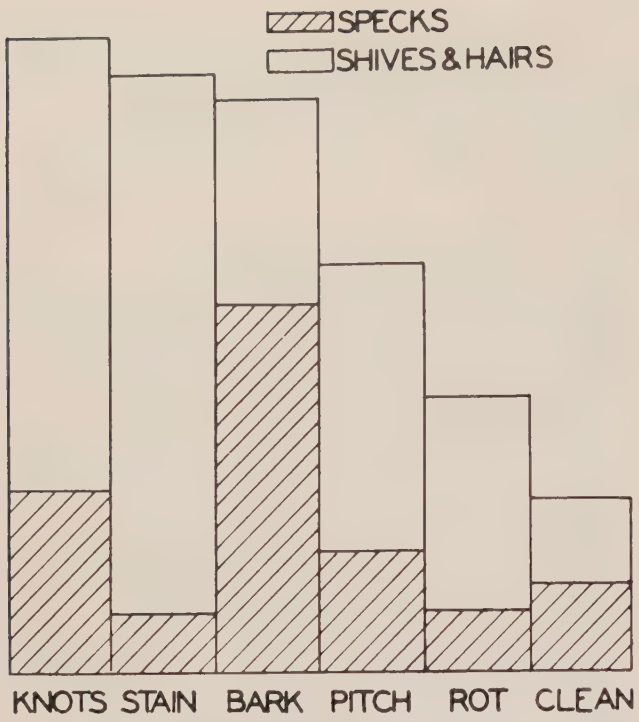

Fig. 1. Distribution of dirt from slab wood

screen plate having 0.010-inch slot openings. The stock was then diluted to 3% consistency to assure a uniform mixture. Samples containing 1 gram of moisture-free pulp were diluted to 250 ml. and agitated for 1 minute with a high-speed agitator to simulate the action in the flumes and pumps in breaking down shives after screening. Handsheets were then prepared for dirt count.

In establishing a method for estimating the dirt content of the handsheets, it was desirable to account for all dirt coming from the wood. Since the customary TAPPI procedure includes only the dirt 0.08 sq. mm. or larger, it was necessary to revise the method to include essentially all the dirt even though it had been broken down to a finer state of subdivision than is usually counted for normal purposes. It was decided that it would be practical to extend the count only to include the smallest speck which could be seen at reading distance, and that the total area of any dirt finer than this size would be negligible.

While no difficulty was experienced in estimating the specks down to 0.02 sq. mm. with the TAPPI dirt estimation chart, it was found difficult and time consuming to estimate the equivalent black area of the many small shives and hairs present in the sheet. To facilitate the latter count a shive estimation chart was designed in which the range of hair and shive area was divided into three size groups of the following approxi-

Table IA. Dirt Balances

Run no.	Speck count, sq. mm./sheet A	B	C	Shive count, sq. mm./sheet A	B	C
Clean	0.074	0.042	0.058	0.188	0.026	0.035
Rotten	0.084	0.010	0.078	1.690	0.084	0.167
Stain	0.041	0.074	0.037	0.280	0.357	0.209
Knots	0.441	0.101	0.098	0.308	0.562	0.193
Pitch pockets	0.110	0.146	0.032	0.212	0.640	0.056
Bark	0.212	0.226	0.155	0.400	0.155	0.053
Total	0.962	0.599	0.458	3.078	1.824	0.713
Unsorted sample	0.965	0.588	0.660	3.090	1.690	1.370
Commercial pulp	0.999	0.630	0.520	2.980	1.593	0.992

Table IB. Dirt Balances

Fraction	Speck count, sq. mm./sheet	Shive count, sq. mm./sheet
Clean	0.042	0.188
Rotten	0.010	1.690
Cambium	0.074	0.280
Knots	0.101	0.380
Pitch pockets	0.146	0.212
Bark	0.226	0.400
Total	0.599	3.150
Unsorted sample	0.588	3.090
Commercial pulp	0.630	2.980

mate equivalent black areas: 0.05, 0.10, and 0.25 sq. mm. For each group the various shapes and colors which the shives of that particular group might assume were made on an illustrated chart. By matching the hairs and shives being counted with those of similar color, size, and shape on the chart, a rapid measure of their size could be obtained. Results obtained with this method by both experienced and inexperienced operators differed by less than 10% of the average count.

The method evolved for evaluating the dirt content of the pulp sheet was then, as follows: twelve dry handsheets were counted for each determination. Each handsheet was prepared from a portion of the screened stock containing 1 gram of moisture-free pulp diluted to 250 ml. and agitated for 1 minute with a high-speed button mixer, formed in a 6 by 6-inch Valley sheet mold, pressed at 100 p.s.i. for 1 minute between two clean blotters, and dried for 1 minute on the hot plate. These sheets were counted under reflected light (standard illumination of 10 c.p.) first for specks and then for shives and hairs. The speck count was made using the TAPPI dirt estimation chart as a reference and counting all dirt specks 0.02 sq. mm. or larger, whereas the hairs and shives 0.05 sq. mm. and larger were counted with the newly devised shive estimation chart. The total dirt content of the sheet was then defined as the sum of the speck and shive areas expressed as square millimeters of equivalent black area per sheet.

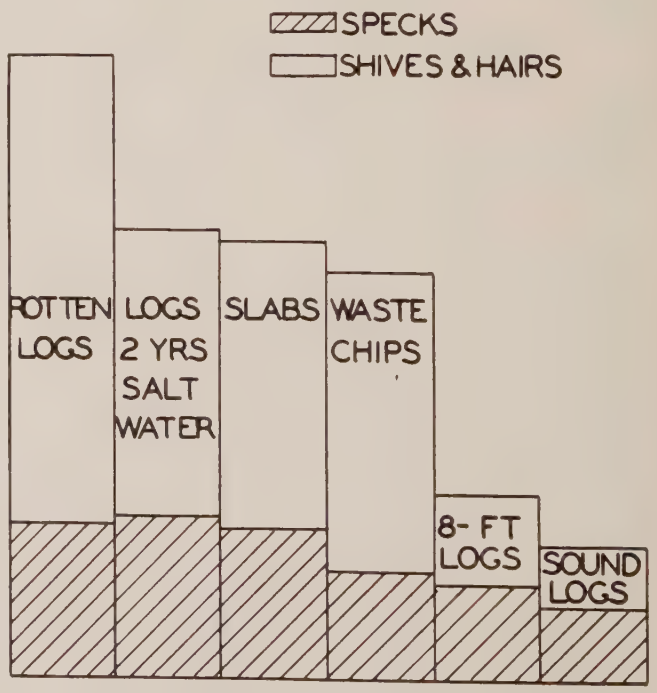

Fig. 2. Relative dirty appearance of pulp produced from various wood supplies

Table II. The Percentage of Dirt Arising from Each Dirt Source for Several Types of Wood

Type of wood	Total dirt content, p.p.m.	Clean		Rotten		Pitch		Knots		Stain		Bark		Worm holes	
		Speck %	Shive %	Speck %	Shive %	Speck %	Shive %	Speck %	Shive %	Speck %	Shive %	Speck %	Shive %	Speck, %	Shive, %
Large sound logs	21.6	13.8	13.8	6.0	4.6	2.2	3.8	27.9	9.0	3.6	9.0	1.6	4.8	...	...
Farmer's logs (8 ft.)	29.7	10.3	3.6	3.6	7.7	4.5	5.5	16.7	13.0	1.0	6.5	12.8	12.3	1.1	1.4
Chipped sawmill waste	65.1	6.2	10.0	1.2	9.3	3.9	6.1	6.5	4.9	3.3	39.0	5.2	2.6	0.5	1.3
Slabs	70.6	3.2	3.2	2.2	8.0	4.6	10.7	6.9	17.0	2.9	19.5	13.8	7.7	...	0.2
Logs in salt water 2 years	72.2	2.8	4.0	0.9	8.4	3.5	9.6	8.8	4.3	0.4	5.3	9.9	10.5	9.4	31.1
Logs containing about 10% rot	99.9	6.0	4.1	5.6	50.1	2.2	3.4	4.1	7.0	1.0	3.9	5.8	6.8	...	...

During the course of this work every effort was made to duplicate plant processing of the chips so that the dirt counts obtained would be about the same as if the processing were done in the plant. To determine whether this purpose had been accomplished, chips were processed by the method outlined, and the dirt count compared with that for commercial pulp produced from the same chip supply. As a further check on the reliability of the method, the sum of the dirt counts for the individual fractions was compared with the dirt count of pulp produced from the unsorted chips. Some typical balances are illustrated in Tables IA and IB.

In the early experiments good dirt balances were not obtained. Investigation disclosed that the difficulty arose because of dirt introduced during the handling of the chip samples. It was found that if both the clean and the dirty chips were washed free of extraneous dirt before they were mixed, a good dirt balance was obtained. This washing operation must be carefully performed, so that no *in situ* dirt will be lost through disintegration of the chips.

EXPERIMENTAL

After the method had been proved experimentally sound, the investigation of typical wood supplies was undertaken. The different types of wood chosen for investigation were as follows:

1. Large logs typical of commercial logging operations.
2. Logs containing large amounts of center rot and brown stringy rot, and cut within 6 months of consumption.
3. Logs that had been stored in salt water for 2 years or longer.
4. Second growth timber harvested and purchased in 8-foot lengths.
5. Slabs and waste wood from sawmill operations.
6. Chips produced from sawmill waste from an outside source.

The logs and slabs were hydraulically debarked and chipped in the sawmill. These chips were then processed in accordance with the method previously described.

The results of typical analyses are tabulated in Table II, and each value is the average of the results obtained from three different samples. The total dirt content of the pulps from the various wood supplies is expressed as parts per million of equivalent black area, and the dirt count attributable to each dirt source is shown as a percentage of the total.

The data in Table II are perhaps more cogently presented in Figs. 1 and 2. Referring to Fig. 1, it is evident, in the case of slab wood, that knots, surface stain, and bark contribute most of the dirt to the final pulp, that the greater portion of the specks come from the bark, and that most of the hairs and shives come from knots and surface stain. Similar graphs could be made for the other wood types, and from them it would be possible to determine: which wood supply should be given the principal attention in the cleaning program, which dirt source or sources it would be most expedient to reduce, and how much dirt reduction could be expected.

The woods have been ranked in Fig. 2 according to the amount of dirt they would contribute to the final pulp. Also illustrated in this figure are the relative proportions of specks and shives making up the total dirt count. This information can be of special importance if a certain type of dirt is particularly objectionable in the product to be made from the pulp. For example, in top liner stock for the manufacture of paperboard the dark hairs and shives are more objectionable than the specks. On the other hand, these dark fibers and shives are almost completely eliminated by bleaching, whereas the bark specks remain relatively unchanged; therefore a wood supply which will yield a large number of specks is undesirable for producing bleached pulp.

CONCLUSION

Since wood supply problems vary with the different mills, it was not intended in this report to cover completely the data gathered in this study. It is rather the intention to describe the method used to gather some data bearing on an important mill program. This information can be used to predict what can be accomplished in dirt removal by selection of wood and cleaning programs. Specifically, predictions can be made on items such as:

1. The dirt content of pulp produced from any combination of wood supplies.
2. The dirt reduction obtainable if special attention were directed toward removing any particular type of wood dirt by extra cleaning in the sawmill.
3. The cost of obtaining pulp of a specified cleanliness by varying the wood supply and/or cleaning the wood. This cost may be compared with the expense of additional dirt removing equipment which might be installed, such as centrifugal refiners, additional screens, etc.

As an illustration, if all the slab wood used at the time of this investigation were eliminated, the dirt content of the pulp would be reduced 10%. Also, if all the brown stringy rot and red heart rot were cut out of the logs, the pulp dirt would be reduced another 15%.

In practice close agreement was noted between results obtained by changes in plant operation and those predicted by the laboratory data.

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The Effects of Machine Head Speed and Specimen Span on Modulus of Rupture Values Obtained in Static Bending Tests of a Nominal $^5/_{32}$-Inch Douglas-Fir Hardboard

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Modulus of rupture values in static bending tests of a nominal $^5/_{32}$-inch Douglas-fir hardboard were determined for 30 combinations of machine head speed and specimen span. Results indicate that employment of unit rates of extreme fiber strain considerably in excess of those currently recommended for evaluating fiberboard produces plateaus wherein modulus of rupture values are virtually constant throughout a relatively wide range of head speeds. The use of greater head speeds suggests that modulus of rupture values so obtained may be adjusted to any arbitrary base for the purpose of comparing the results of different investigators and that testing time may be shortened materially.

METHODS of evaluating not only experimental but also commercial hardboards have occupied the attention of the Oregon Forest Products Laboratory for several years. Among the problems that have confronted this laboratory are the following: (1) Can modulus of rupture values determined by various investigators using different test procedures be correlated well enough to make more direct comparisons? (2) What method employing standard equipment for evaluating the flexural strength of hardboard will give modulus of rupture values that are least influenced by minor variations in testing procedure? (3) In the interest of laboratory efficiency, is it possible to use a less time-consuming testing procedure to obtain modulus of rupture values that may be adjusted with reasonable accuracy to those determined by slower methods now in use?

Early hardboard evaluations at this laboratory revealed the fact that flexural strength determinations, for any given thickness of hardboard, varied with testing speed and specimen span. These results suggested that modulus of rupture values obtained from static bending tests depended upon the rates at which stresses were developed within the material or, stating the case differently, upon the rates of fiber strain. As a consequence, an investigation of the effects of variations in machine head speed and specimen span on modulus of rupture values was undertaken. The interrelationships of these variables, as shown by tests on one thickness of a Douglas-fir hardboard, are reported herein.

The first specifications issued for hardboard testing were contained in Federal Specification LLL-F-311, March 9, 1939 (*2*). These specifications required a modulus of rupture specimen 3 inches wide and not less than 12 inches long, tested on an 8-inch span at a head speed of 4 inches per minute.

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The U. S. Forest Products Laboratory recognized the importance of head speed and span on the flexural strength of fiberboards in its report R1717, June, 1948 (*5*) and made recommendations for static bending tests. These proposals are also included in the May, 1949, revision of its report R1712 (*4*) and in ASTM Designation D 1037–49 T (*1*) covering tentative methods of test for evaluating the properties of building boards.

Static bending tests in the ASTM tentative methods call for a test specimen 3 inches wide when the board thickness is greater than $^1/_4$ inch and a specimen width of 2 inches when the thickness is $^1/_4$ inch or less. The length required in each test specimen is 2 inches plus 24 times the board thickness. The span for each test is to be 24 times the nominal thickness, and the load is to be applied at a uniform rate of speed. This rate of head speed is calculated from the span and depth of specimen to give a unit rate of outer fiber strain of 0.005 inch per minute per inch of length.

FABRICATION OF EXPERIMENTAL BOARDS

Nominal $^5/_{32}$-inch hardboard, made from old-growth Douglas fir salvaged from the Tillamook burn, was selected for testing. The wood was converted into $^5/_8$-inch chips and steamed at 45 pounds pressure for 45 minutes. Cooked chips were fiberized in a 24-inch diameter, double-rotating-disk Bauer mill at a plate clearance of 0.005 in.

The pulp was formed into ten 24 by 24-inch mats in a suction mold. Each mat was marked to identify the position in which it was formed. Mats were pressed on top of a 16-mesh screen between stainless steel cauls in a 24-inch, 150-ton capacity, steam-heated press. The edge of each mat, marked as the front edge in the forming box, was placed in the front of the opening of the hot press. Mats were pressed at 360°F., using a three-stage pressing schedule: (1) 500 p.s.i. for 1 minute, (2) release of pressure for a breathing period of 2 minutes, and (3) final drying of the board at a pressure of 215 p.s.i. for 10 minutes.

The boards were conditioned at 75°F. and 68% relative humidity for 2 weeks prior to testing. After this conditioning, the average thickness of the boards was 0.152 inch.

Spans of 2, 3, 4, 6, and 8 inches at head speeds of 0.06, 0.60, 1.0, 2.0, 4.0, and 6.0 inches per minute, a total of 30 combinations of span and head speed, were used in this study. Ten specimens (one from each 24-inch board) were tested for each combination. The locations of the test specimens were selected at random so that a specimen tested under any given head speed

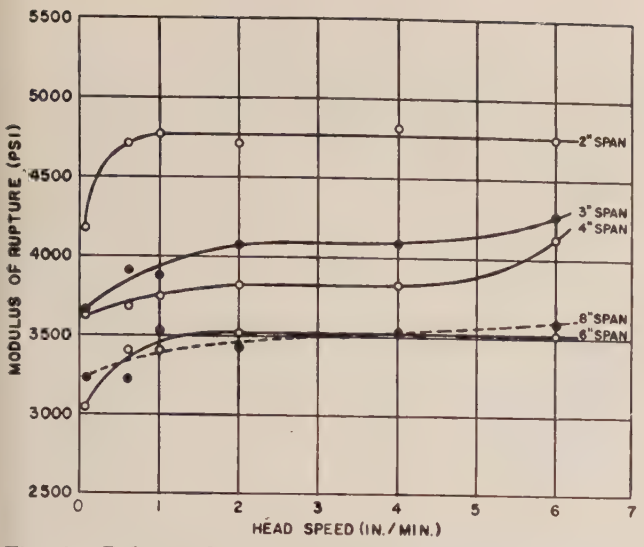

Fig. 1. Relationships between head speed, modulus of rupture, and span for a Douglas-fir hardboard 0.152 inch thick

and span might come from any part of the board. This randomization was accomplished by ruling (with allowance for saw kerf) each board into ten 2-inch strips. Half of the boards were ruled normal to and half were ruled parallel to their front edges. Each strip was divided into thirds by drawing two lines normal to its edge. The resultant rectangular areas were numbered 1 to 30 on each of the ten boards used. A series of 30 corks was prepared by marking each with one of the 30 combinations of head speed and span. These corks were shaken in a beaker and then drawn one by one, each drawing being assigned consecutively to one of the numbered areas marked on the surface of one of the 24 by 24-inch hardboards. Such drawing was repeated until each test specimen area on the ten boards had been assigned a head speed and span combination. The test specimens were then cut from the boards, and flexural tests were performed according to the markings for head speed and span indicated thereon. After the flexural tests were completed, a 1 by 2-inch coupon for determination of specific gravity was taken from each test specimen as close to the break as possible.

RESULTS

The average specific gravity for the 300 test specimens was 0.89, based on volume at test and oven-dry weight. The modulus of rupture value for each test was adjusted to the average specific gravity according to the method suggested by Turner, Hohf, and Schwartz (*3*) in which the modulus of rupture is assumed to be directly related to the square of the specific gravity. The ten adjusted modulus of rupture values for each head speed and span combination were averaged to give an average value for the ten boards from which the test specimens were taken. The modulus of rupture averages for the 30 combinations of head speed and span were compared to determine the effects of these two testing variables.

Figure 1 shows the relationships between modulus of rupture and head speed at the several spans tested. These data clearly indicate that the modulus of rupture values increased as the span was shortened from 6 to 2 inches.

Throughout much of the range of head speeds employed, modulus of rupture values for the 8-inch span are substantially the same as those obtained for the 6-inch span. For the 8-inch span, each increase in head speed gave a slight increase in modulus of rupture. Increases in head speed up to 1 or 2 inches per minute produced increases in modulus of rupture values for spans of 2 to 6 inches.

Of particular interest is the fact that virtually constant modulus of rupture values for each span, within the range of 2 to 6 inches, were obtained with head speeds of 2 to 4 inches per minute. Head speeds in excess of 4 inches per minute produced no increase in modulus of rupture for spans of 2 and 6 inches, but they gave rather sizable increases for spans of 3 and 4 inches.

The modulus of rupture value for the 6-inch span and a head speed of 4 inches per minute was arbitrarily selected as the base for computing percentage variations in modulus of rupture values for the different combinations of head speed and span. These percentage deviations are shown in Fig. 2.

Head speed and the rate of outer fiber strain are related by the following equation (*5*):

$$z = \frac{6dN}{L^2}$$

where

z = rate of fiber strain, inches per minute per inch
d = thickness of fiberboard, inches
L = length of span, inches
N = head speed, inches per minute

A head speed of 4 inches per minute and a span of 6 inches gave a unit rate of fiber strain of about 0.10 inch per minute per inch for the material tested. Taking the modulus of rupture obtained under these conditions as the base, percentage deviations in modulus of rupture were plotted against rate of fiber strain for the spans used (Fig. 3). For the 6-inch span, the modulus of rupture values remained virtually constant for rates of strain between the limits of about 0.06 to 0.15 inch per minute per inch of length.

Figure 4 shows the combinations of machine head speed and span that produce various unit rates of extreme fiber strain in a hardboard 0.152 inch thick.

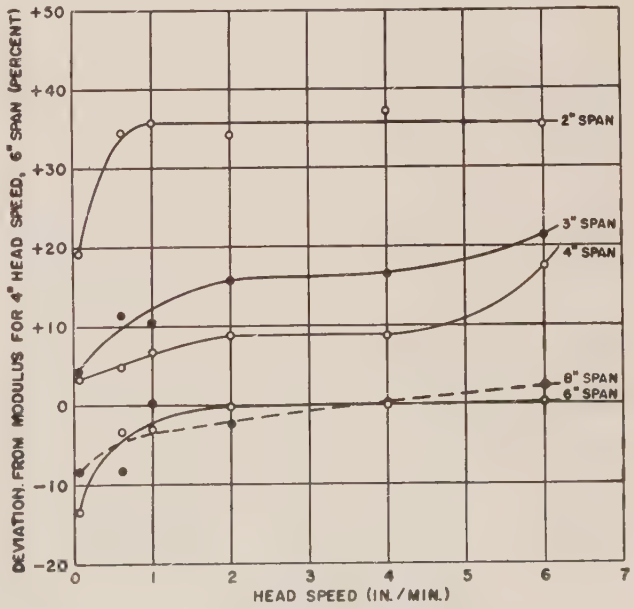

Fig. 2. Relationships between head speed, span, and percentage deviation from the modulus of rupture value for a head speed of 4 inches per minute and a 6-inch span

DISCUSSION

The results of this study indicate that a headspeed of 4 inches and a 6-inch span gave the least variable modulus of rupture value for a nominal $^{5}/_{32}$-inch Douglas-fir hardboard. These test conditions conform more nearly to the Federal Specification LLL-F-311 than to the tentative ASTM methods for evaluating fiberboards. The ASTM tentative methods call for a head speed producing an extreme fiber unit rate of strain of 0.005 inch per minute per inch of length. To meet this requirement for the thickness of fiberboard used in this study, a head speed of 0.075 inch per minute and a span of 3.75 inches (24 times the nominal thickness of $^{5}/_{32}$ inch) should have been employed. Inspection of Figs. 2 and 3 shows that small variations from a head speed of 0.075 inch per minute and a rate of fiber strain of 0.005 inch per minute per inch would produce sizable changes in the modulus of rupture values obtained, irrespective of span. The choice of a span 24 times the nominal thickness of the board used in this study does not seem to be satisfactory; the 6-inch span, which gave the least variable modulus of rupture, corresponds to a span-thickness ratio of almost 40 to 1.

Within the range of machine head speeds and specimen spans employed in this investigation of variation in modulus of rupture values (adjusted for specific gravity differences) of a nominal $^{5}/_{32}$-inch Douglas-fir hardboard, the following observations are noted:

1. With increase in head speed, modulus of rupture values for the 8-inch span increased rather gradually throughout the entire range of head speeds. For the 2 and 6-inch spans, the modulus of rupture values increased sharply up to head speeds of about 1 and 2 inches per minute, respectively, and then leveled off with the application of greater speeds. Modulus of rupture values for the 3 and 4-inch spans increased rather rapidly up to a head speed about 2 inches per minute, then leveled off at head speeds of 2 to 4 inches per minute, and finally increased rather sharply as greater head speeds were used.

2. Higher modulus of rupture values were obtained at given head speeds and unit rates of strain as the span was decreased, progressively, from 6 to 2 inches. Modulus of rupture values for the 8-inch span, although somewhat at variance, were in rather close agreement with those for the 6-inch span.

3. With the exception of the 8-inch span, the curves

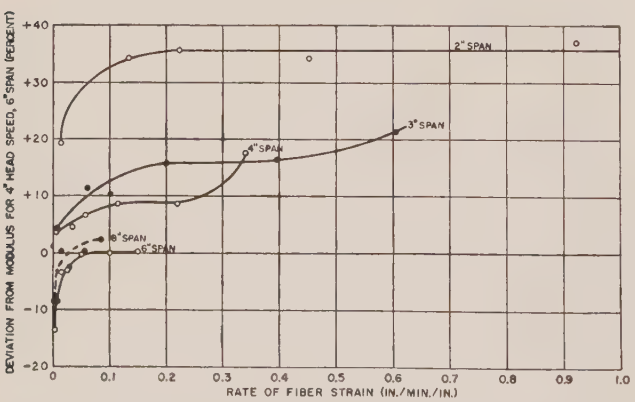

Fig. 3. Relationships between rate of strain, span, and percentage deviation from the modulus of rupture value or a head speed of 4 inches per minute and a 6-inch span

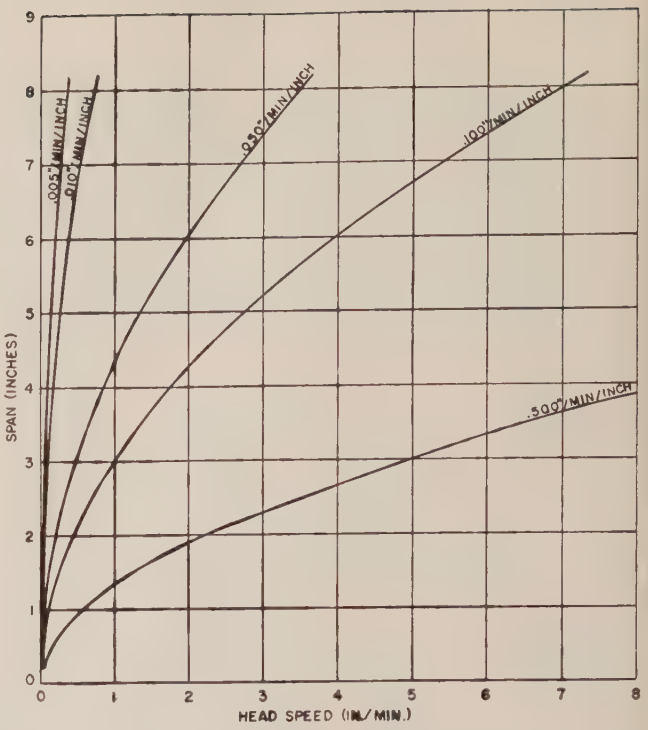

Fig. 4. Head speeds and spans necessary to produce various unit rates of strain in the extreme fiber of a Douglas-fir hardboard 0.152 inch thick

for all other spans revealed plateaus of virtually constant modulus of rupture values that extend over a relatively wide range of head speeds. The head speeds corresponding to the limits of these plateaus are considerably in excess of those currently recommended for evaluating hardboard.

In view of the results obtained with the hardboard used in this study, the following conclusions are reached:

1. A machine head speed of 4 inches per minute and a specimen span of 6 inches, producing an extreme fiber unit rate of strain of 0.10 inch per minute per inch of length, gave the most satisfactory modulus of rupture values.

2. By utilizing the head speeds associated with the plateaus of constant modulus of rupture values for spans of 6 inches or shorter, (1) constant-percentage adjustments could be used to convert test results to any arbitrarily selected base, (2) minor variations in head speed will not affect the modulus values obtained for these spans, and (3) testing machine operating time can be reduced materially, especially for the longer spans.

3. This investigation should be extended to include hardboards of other thicknesses and formulations.

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Notes on Weight Factors for Fiber Microscopy

JAMES d'A. CLARK

The weight factor of a fiber is proportional to its average weight per unit length, which may be determined by simple projection means (see *Tappi* 25: 560). The factor is then calculated in comparison with standard rag fiber which may be defined as having a weight factor of 1.00 with a grex (grams per 10,000 meters) of 1.80. As a new empirical rule for determining the percentage of unfamiliar fibers in a sample, their weight factors tentatively may be taken to be their average width in microns, divided by 20 for rag, 30 for coniferous, and 35 for deciduous or grass fibers.

THE most commonly used method of estimating the fiber furnish of a sample of paper is to pulp it, mount and differentially stain the fibers on a microscope slide, traverse the slide under a dot in the eyepiece, count the number of passes over the different fibers, multiply the counts by appropriate weight factors to transform the counts into weights, and report the percentages.

Following some extensive work by Graff (*1*, *2*), Isenberg and Peckham (*3*) have reported recently on the changes to the weight factors for cotton linters upon beating. To the writer, it seems a pity that all these careful investigations into the effects of beating were based on freeness (G.D.). The only connection between weight factors and freeness is the relatively minor effect, especially with pulps other than from cotton or bast fibers, which the lengthwise splitting of the fibers has in reducing the freeness. During beating, fibers are split apart to an extent depending on their nature and on the beating conditions; freeness is reduced mainly by the production of debris. Thus, weight factors and freenesses cannot possibly be consistently correlated.

When a fiber is separated lengthwise, its weight factor is halved. The weight factor of a fiber depends on and varies directly with its average weight per unit length. A suitable unit of measurement for this purpose is the International Denier or "grex"—the weight in grams of a length of 10,000 meters of the fiber. This raises the question of what is a fiber. The observer who considers all elements having widths over 0.2 mu to be fibers, will obtain lower weight factors (relative to unbeaten "rag") than another, like the writer, who prefers to count only those over 1 mu thick (unless all the fibers in the sample are very highly beaten). Until the minimum width of fibrous elements is agreed, weight factors, especially for well beaten pulps, cannot be standardized with accuracy.

The selection of a weight factor unit based on "rag" was a doubly unfortunate choice, not only because of the indefinite nature of "rag" fibers but also because rag fibers readily split lengthwise during beating, especially if of linen, whereas the most commonly used pulps from wood and grasses do so only with difficulty. In consequence, the weight factor of a fiber, using unbeaten rag for comparison, will progressively *decrease* as it is split by beating. On the other hand, if the weight factor of a wood or grass fiber be determined from a mixture of it and rag fibers beaten together, its weight factor will progressively *increase* with beating because the rag fibers will separate lengthwise much more readily. Evidence of this may be seen by inspecting the data in Table III of reference (*1*).

The weight per unit length of fiber may be determined with a microscope (*4*) or by the faster and perhaps as accurate method devised by the writer (*5*). As calculated from the data in Table I of the latter reference, the grex of a West Coast bleached hemlock pulp was 1.75 unbeaten, 1.67 after beating it for 8 r.p.g. in a kollergang which is equivalent to that needed for an average bond paper, 1.52 for 32 r.p.g., and falling to 1.39 grams per 10,000 meters after beating for the excessive degree of 64 revolutions per gram of pulp treated. The weight factors for this pulp, based on unbeaten rag, would decrease at the same slow rate.

Using the data from Table VIII of reference (*4*) and based on rag having a weight factor of 1.00 and a grex of 1.8, the weight factors of the other fibers were calculated by multiplying the grex by this ratio, or 0.55. These are included in the attached Table I. Except for the southern pine, for which the normal grex is estimated to be nearer 2.7 than 1.62, the calculated weight factors check quite well with those given in the literature (*2*) and with TAPPI Standard T 401 m-42.

Since with unknown fibers in a sample, one cannot determine their grex very well, and certainly not their freeness, recourse must be made to another approach, one of which is as follows: Estimate the average width of each kind of the fibers in the sample in microns (by

Table I. Actual and Calculated Weight Factors for Various Fibers

Fiber	*Grex, g./10³ m.*	*Weight factor from grex*	*Av. width, mu*	*Weight factor from width*	*Weight factor Graff (2)*
Rag	1.8	1.00	(20)[a]	1.00	1.00
Cotton linters	...	...	(30)[a]	(1.5)	1.5
Paper mulberry	...	...	25	1.25	1.3
Manilla	...	...	20	1.0	0.75
Mitsumata	...	...	10	0.5	0.35
Coniferous					
Southern pine	1.6 (2.7)[a]	0.9 (1.5)	32–46	1.05–1.55	1.55
Western hemlock	2.45	1.3	28–35	0.95–1.15	1.2
Scandinavian	...	...	27–32	0.9 –1.1	1.0
Eastern U. S.	1.6	0.9	25–28	0.8 –0.9	0.8
Alpha	1.5	0.8	22–27	0.7 –0.9	0.7
Deciduous					
Sulphate	...	...	...	...	0.7
Sulphite	1.2	0.65	...	...	0.6
Soda	0.85	0.45	...	...	0.5
Alpha	0.9	0.5	...	...	0.55
Black gum	...	...	28	0.8	1.0
Birch	...	...	20	0.55	0.65
Poplar	...	...	22	0.6	0.55
Maple	...	...	16	0.45	0.45
Grass					
Bamboo	...	...	18–27	0.5 –0.75	0.55
Esparto	...	...	12	0.35	0.5
Groundwood	...	...	(40)[a]	(1.3)	1.3

[a] Estimated values.

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inspection). Divide this width by 20 if a rag or bast fiber, by 30 if a coniferous wood fiber, or by 35 if a deciduous wood fiber or a grass, to get the approximate weight factors to apply. As will be seen also in Table I application of this empirical rule gives fair results with the limited data available. It should be borne in mind that the data in the different columns of Table I were not derived from the same samples of each species.

Determining the weight factors of various pulps by measuring their grex is, without doubt, the most accurate approach and a relatively very easy one if facilities are available. On the other hand, the width rule, just given, is certainly crude and could be improved with better data, perhaps using the estimated cross-sectional area of the fibers as a basis. Nevertheless, crude as it is, until further work uncovers a better approach, it is believed that its application will permit of greater accuracy in the analysis of unfamiliar samples than will the blind use of fixed group weight factors as at present.

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Ammonia-Base Sulphite Pulping Liquors—Their Preparation and Analysis

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The Palmrose method for determining SO_2 in sulphite cooking liquors has been combined with the formol-titration method for determining NH_3. Using one sample of liquor it is possible to obtain total SO_2, free SO_2 and NH_3. The levels of NH_3 concentrations are not explicitly given in previous work on ammonia base liquors. The potassium iodate used in the Palmrose method converts sulphites to sulphates which will react with formaldehyde to produce sulphuric acid and this in turn can be titrated with a base to give equivalent NH_3. The procedure cannot be reversed due to the addition products formed when sulphites are added to the aldehyde. Apparatus has been set up to study some of the variables encountered in preparing the liquors. Data are presented showing the correlation between pH values obtained in a closed batch recycle system and analyses as obtained by the above procedures. The use of pH meters in measuring and controlling ammonia concentrations is not recommended; there is more promise for them during the SO_2 absorption phase both in acid and neutral solutions.

An extensive program has been initiated to investigate the yields and qualities of chemical pulps produced from certain Texas woods, and from other cellulose-bearing materials such as cotton linters, straws, hulls, wood waste, or others. The apparent fact that the use of ammonia-base sulphite cooking liquors may offer some advantages over conventional cooking processes as well as the latitude of concentrations and pH's available has prompted experiments with the ammonia-sulphur dioxide-water system.

Previous investigators, Benson and co-workers (*1*, *2*), Hepher and Jahn (*3*), Jenness and Nystrom (*4*), Marriner and Whitney (*6*), briefly describe their acidmaking techniques and report the customary free and combined sulphur dioxide percentages, based on TAPPI procedures (*9*) or the Palmrose one (*8*) but not the amounts of ammonia present in their solutions. This article is based on experiments which attempt to show a correlation between amount of ammonia and sulphur dioxide (and its distribution) and some property of the resulting solutions.

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ANALYTICAL BACKGROUND

The Palmrose method was chosen for the SO_2 determinations based partly upon the comparative studies made by McMasters (*7*). By this method the sulphite present is oxidized to sulphate with potassium iodate. Potassium iodide is formed in the reaction which is a time one leading to questionable results in getting end points in weak solutions. However, if excess potassium iodate is added to the solution in the presence of sulphuric acid, iodine is released and reacts with sulphurous acid to form hydriodic acid; these reactions are relatively rapid and lead to acceptable end points. Free SO_2 is found in the same sample by titrating to a methyl red end point.

It was next attempted to find the ammonia present in the solutions, preferably in the same sample used above. The traditional Kjeldahl method seemed unsatisfactory except for comparative purposes, and search for other methods led to a study of the formol titration, Kolthoff and Stenger (*5*), Welcher (*10*). In this reaction the solution to be tested is first neutralized and to this neutral solution is added an excess of a formaldehyde solution. The ammonia reacts with the formaldehyde forming an acid that can be neutralized by titration with a base. The reaction may be written:

$$2CH_2O + (NH_4)_2\,SO_4 = 2CH_2O\,HNH_2 + H_2SO_4$$

It must be remembered that the presence of sulphite ions makes the above inoperative due to the addition product formed, Wertheim (*11*) such as:

$$CH_3\,CHO + NaHSO_3 = CH_3\,CHOH\,SO_3Na$$

It was mentioned that the sulphite was oxidized to sulphate in the Palmrose method and that the free SO_2 was found at a methyl red end point which is just the condition needed to start the ammonia-formol titration. Combining these allows one to obtain total

and free SO_2 and NH_3 on one sample. In preliminary tests it was found that titrating the acid in the ammonia-formol reaction with sodium hydroxide gave a very slow end point. For this reason, and the recommendations of Sorrentino, Welcher (*10*), the sodium hydroxide was replaced by barium hydroxide. This base gives a milky precipitate of barium sulphate against which the red end point is easily detected and in addition gives a much sharper color change than that obtained with sodium hydroxide.

LABORATORY PROCEDURE

To a 250-ml. Erlenmeyer flask are added 50 ml. of distilled water, 5 drops of methyl red indicator solution, and 2 ml. of starch-potassium iodide solution. The solution should be orange or yellow at this point. Of the liquor to be tested 2.00 ml. are pipetted to the flask and titrated with $N/8$ potassium iodate solution. The flask is not shaken during titration until the blue color begins to appear. After a permanent blue color is reached, the solution is decolorized with a drop of sodium thiosulphate solution and titrated with $N/8$ sodium hydroxide solution to the methyl red end point. Then 10 to 15 ml. of C.P. formaldehyde solution that has been neutralized to a phenophthalein end point is added to the solution in the flask. The solution is allowed to stand for at least a minute before titration with $N/4$ $Ba(OH)_2$ solution to a phenophthalein end point. The starch-KI solution used is a 1% starch solution to which 1% KI has been added. The barium hydroxide solution must be frequently standardized and protected against CO_2 from the atmosphere. The potassium iodate solution must be kept in a dark bottle and also protected against CO_2. This solution was found to be stable under these conditions.

The per cent total SO_2 is 0.2 (ml. KIO_3 solution used) ($N/8$ factor of KIO_3 solution).

The per cent free SO_2 is 0.2 (ml. NaOH solution used) ($N/8$ factor of NaOH solution).

The per cent ammonia (as NH_3) is 0.2125 (ml. $Ba(OH)_2$ solution used) ($N/4$ factor of $Ba(OH)_2$ solution).

These percentages are reported on the assumption that the specific gravity of the liquor is 1.0, following customary practice, Palmrose (*8*); actually the results are more accurately stated as grams of component per 100 ml. of solution. Determinations with a specific gravity balance on some of the solutions have justified the above basis, but future workers should be warned about possible large differences in the two methods of reporting analyses.

The analytical method presented here is believed to give results having all the accuracy desired. The formol-titration method of ammonia analysis was checked carefully, using the above procedure. The results were checked by both the Kjeldahl method and by an acid titration of the ammonia solution before adding sulphur dioxide. This latter method was considered the best check, since the laboratory procedure was much simpler. In Table I some data are shown giving the per cent error encountered at various ammonia concentrations. These errors are expressed on the basis of the results obtained from the formol titration method, in other words as the per cent of the measured value that is in error. The per cent error, of course was greatest at low concentrations, while the absolute error remained in the same range throughout. Some of the tests were run using a 1-ml. sample of liquor instead of a 2-ml. sample. This tended to increase the error some because of greater inaccuracy in volume measurement. Probably the greatest source of error is in the methyl red end point. Any deviation from the exact end point can cause considerable error in the calculated ammonia content. This effect is particularly noticeable at small ammonia concentrations. It is also very important to keep the formaldehyde solution exactly neutral. By using as strong a formaldehyde solution as possible, the volume of this reagent needed is reduced, which tends to cut down any error caused by its deviation from neutral.

PREPARATION OF LIQUOR

As a preliminary step to running pulping tests with ammonia-base pulping liquor it was necessary to design equipment for preparing the liquor. It was not yet known just what concentrations of solution would be used for these tests, so it was necessary to find a method of preparing, on demand, solutions with a wide range of concentrations.

Table I. Comparison of Results from Acid-Titration and Formol-Titration Method for Ammonia Determination

No.	*% NH_3 determined by acid titration*	*% NH_3 determined by formol titration*	*Size of sample used in formol titration, ml.*	*% Error based on formol titration*
1	4.00	4.05	2	1.23
2	4.00	4.08	1	1.95
3	2.82	2.80	2	−0.71
4	2.82	2.84	2	0.71
5	2.10	2.01	1	−4.5
6	1.41	1.39	1	−1.44
7	0.920	0.930	2	1.08
8	0.609	0.620	2	1.78
9	0.358	0.369	2	2.98

Other investigators, Benson and co-workers (*1*, *2*) prepared their solutions by simply bubbling the two gases, sulphur dioxide and ammonia, into a carboy of water. Using this method the concentrations cannot be easily regulated and the solution desired must be obtained by trial and error. Hepher and Jahn (*3*) obtained their solutions by dissolving C.P. crystals of $(NH_4)_2SO_3H_2O$ in water. They made some runs using only the neutral salt in solution, some with added ammonium hydroxide, and some with added sulphurous acid. This procedure permits better control of the preparation of liquor, but is expensive and unnecessarily tedious for work involving many solutions.

In order to prepare a pulping solution of a given concentration, the correlation of some variable of the solution with concentration must be determined. The variable chosen must vary in some regular manner with the concentration of the solution, and the variable must be easily measured. Equipment designed for the absorption of ammonia and sulphur dioxide can then be used in conjunction with a measuring device that indicates the concentration of the solution formed.

In designing equipment for preparing pulping liquor the first problem was to choose a solution variable to use as an indication of concentration. Marriner and Whitney (*6*) used the partial pressure of the sulphur dioxide in solution as an indication of the concentration.

They investigated the partial pressure of sulphur dioxide over a wide range of sulphur dioxide concentrations and for various ammonia concentrations. This research was primarily aimed at investigating the solubility of sulphur dioxide in an ammonia solution. The results obtained from this investigation indicated that the pressure of sulphur dioxide is not a reliable measuring variable in the case of ammonia-base solutions. Ammonia cannot be kept completely in solution and interferes with the pressure measurements. In addition the process of measuring partial pressure is not suited to a rapid preparation procedure in which the concentration must be determined continuously.

Whittimore, Dryden, and Aronovsky (*12*) investigated the conductometric analysis of ammonia-base sulphite pulping liquors. They were primarily interested in making conductometric titrations of spent liquors that were too dark in color to titrate with a colored indicator. They were able to demonstrate the end points obtained when several synthetic compounds commonly found in spent liquor were analyzed by conductometric titration, however, they made no attempt to apply the method to actual spent liquors or the preparation of pulping liquor. It is believed that the conductance of a solution might be used as a criterion of concentration in the preparation of pulping liquor in a flow system.

The variable that was finally chosen for the investigation presented here was the pH of the solution. Initially it was believed that the change of pH as ammonia was added to water, and as sulphur dioxide was added to the ammonia solution, could be used as an indication of the concentration. The pH of a solution in either static or flow systems is relatively easy to measure.

To use pH as a measure of concentration it was first necessary to discover the correlation between pH and concentration and then plot the data into curves. It was thought that the first curve needed was the variation of pH as ammonia was absorbed in water. Then a series of curves showing the pH variation of various ammonia solutions as sulphur dioxide was absorbed could be constructed. To use such curves it would be necessary only to watch the pH change as ammonia is added to the system and stop the absorption process when the desired concentration is reached. This point could be determined by reading the pH of the desired solution from the curve of pH plotted against ammonia concentration. Then the second series of curves could be examined to find the pH of a solution having the known ammonia concentration and some desired concentration of sulphur dioxide. It would probably be necessary to interpolate between the curves for various ammonia concentrations. Adding sulphur dioxide to the prepared ammonia solution until the pH reaches the predetermined value should give a final solution with the concentration sought.

To carry out the pH method of continuous analysis the first step was to prepare the curves. The pH's were measured on a Beckman line-operated pH meter, model H-2. The buffer solutions used to standardize the instrument were a pH 10 buffer prepared by the National Technical Laboratories, and a pH 7 buffer (21073A) prepared by the Central Scientific Co. The electrodes used were a Beckman glass electrode and a calomel electrode.

Measuring the pH of various ammonia solutions gave the data shown in Table II. These data are shown plotted in Fig. 1. The curve shows that the pH of ammonium hydroxide solutions increases very rapidly up to approximately 0.05% ammonia, then increases slowly from 0.05 to about 1.0%, and then even more slowly beyond 1.0% ammonia. Because of the shape of this curve it would be very difficult to use in correlating concentrations with pH measurements. At extremely low concentrations the curve might be used satisfactorily but above 0.5% ammonia it does not seem advisable to attempt to obtain concentrations from pH measurements.

Table II. Variation of pH with Per Cent NH_3 in Solution

Per cent NH_3	*pH of solution*
0.036	10.49
0.051	10.61
0.132	10.89
0.358	11.39
0.609	11.57
0.920	11.63
1.41	11.70
2.10	11.81
2.82	11.89
4.00	11.99
9.67	12.06

For various solutions of ammonium hydroxide the change of pH with sulphur dioxide concentration was measured. These results are tabulated in Table III and plotted in Fig. 2. Since the sulphite ion is bivalent, while the ammonium ion is monovalent, it is possible to obtain both an acid and neutral salt in these solutions. This fact is clearly shown in the double inflection points obtained. The curves plotted in Fig. 2 are more usable for concentration determinations than those shown in

Table III. Variation of pH with SO_2 Concentration in Solutions of Various NH_3 Concentration

I % NH_3 0.358		*II* % NH_3 0.609		*III* % NH_3 0.920		*IV* % NH_3 1.41		*V* % NH_3 2.10		*VI* % NH_3 2.82		*VII* % NH_3 4.00	
% total SO_2	*pH*	% total SO_2	*pH*	% total SO_2	*pH*	% total SO_2	*pH*	% total SO_2	*pH*	% total SO_2	*pH*	% total SO_2	*pH*
0.0	11.39	0.0	11.57	0.0	11.63	0.0	11.70	0.0	11.81	0.0	11.89	0.0	11.99
1.07	6.22	1.74	6.42	2.76	6.25	3.11	6.75	4.67	6.63	6.80	6.39	11.41	7.78
1.17	5.92	1.89	6.20	3.02	5.90	3.39	6.41	5.03	6.43	7.19	6.17	12.41	5.88
1.32	4.01	2.09	5.80	3.42	4.90	3.69	6.22	5.30	6.30	7.56	6.12	13.46	5.61
1.62	2.51	2.51	2.90	3.90	2.70	3.94	6.05	5.92	6.07	8.05	5.87	14.31	5.24
1.99	2.22	3.00	2.30	4.52	2.30	4.27	5.80	6.21	5.99	8.58	5.63	15.00	4.57
2.33	2.10	3.48	2.10	5.13	2.08	4.69	5.40	6.63	5.67	9.31	5.27	15.83	3.12
2.76	1.90	3.96	1.98	5.91	1.98	5.15	3.43	7.22	4.79	9.82	4.73	16.90	2.62
		4.62	1.80	6.50	1.81	5.68	2.57	8.18	2.80	10.69	2.82	18.90	2.31
		5.30	1.71	7.30	1.75	6.21	2.35	9.54	2.30	11.56	2.47		
		6.10	1.63	8.05	1.70	7.04	2.18			12.50	2.17		
		6.85	1.51	9.27	1.63	7.81	2.12			13.64	2.11		
		8.02	1.40										

Fig. 1. Except at very low ammonia concentrations the curves display reasonably moderate changes of pH with concentration. In no case would the determination of concentration with pH at very high sulphur dioxide concentration be accurate. This limiting of the pH value at the lower end of the scale is probably again a result of limited ionization at these greater concentrations. Even in fairly high sulphur dioxide concentrations, however, a relatively close approximation to the true concentration could be made.

During cooking tests it may become desirable to use cooking liquors of some specified pH. For this case the curves of Fig. 2 may be replotted for various constant values of pH. Two such curves are shown in Fig. 3. These curves are for a pH of 7 and a pH of 2.5. The data needed to plot the pH 7 curve were obtained from the extrapolated portion of the curves in Fig. 2.

It would be desirable to investigate thoroughly the system ammonia-sulphur dioxide-water to get a clearer picture of the compounds present in liquor at various concentrations. It was beyond the scope of this research to investigate this system completely, however, some data were obtained. On one of the runs (see Curve VI, Fig. 2), the analyses were made more completely than the rest and from this run the data of Table IV were obtained. These data are shown plotted in Figs. 4 and 5.

APPARATUS

A flow diagram of the system built to prepare ammonia-base sulphite pulping solutions is shown in Fig. 6. This apparatus was designed to prepare the solutions rapidly and at the same time to permit control of the concentration. It is of laboratory scale, being designed to make up to 15 gallons of liquor in each batch. The equipment is actually a batch-type absorption system. It consists primarily of a closed circulation system around which the solution is pumped, while gas is injected into the stream, and the pH of the solution is measured. This design was necessary since restricted space made extensive absorption equipment impossible. It was found necessary to build the apparatus from stainless steel or aluminum to overcome the strong corrosive action of sulphite liquor. As a result the piping is aluminum while the valves are stainless steel. The main storage system is a large glass carboy.

In preparing solutions the first step is to fill the carboy with water. While this is being done the vent line is closed long enough to force water through the suction

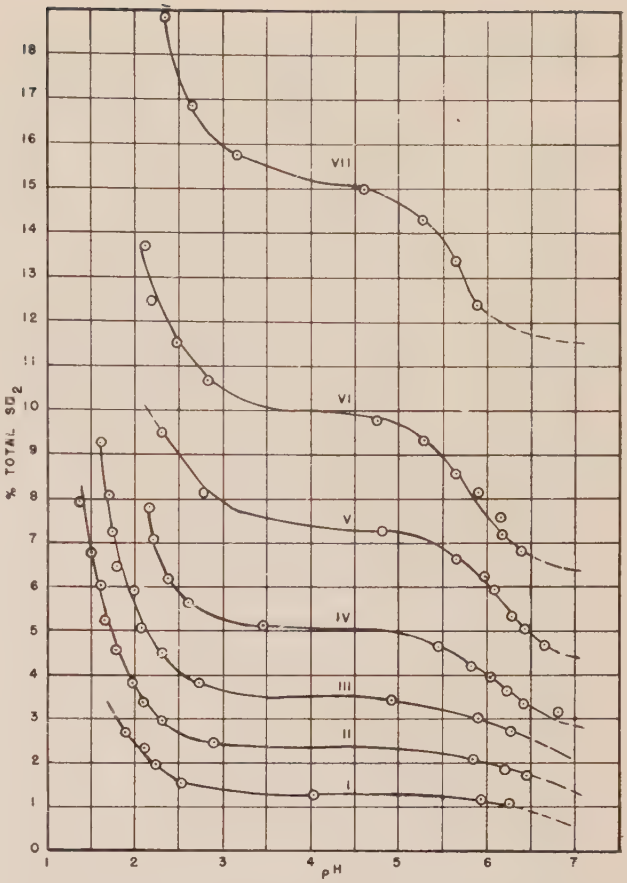

Fig. 2. Variation of pH with SO_2 concentration in solutions of various NH_3 concentrations

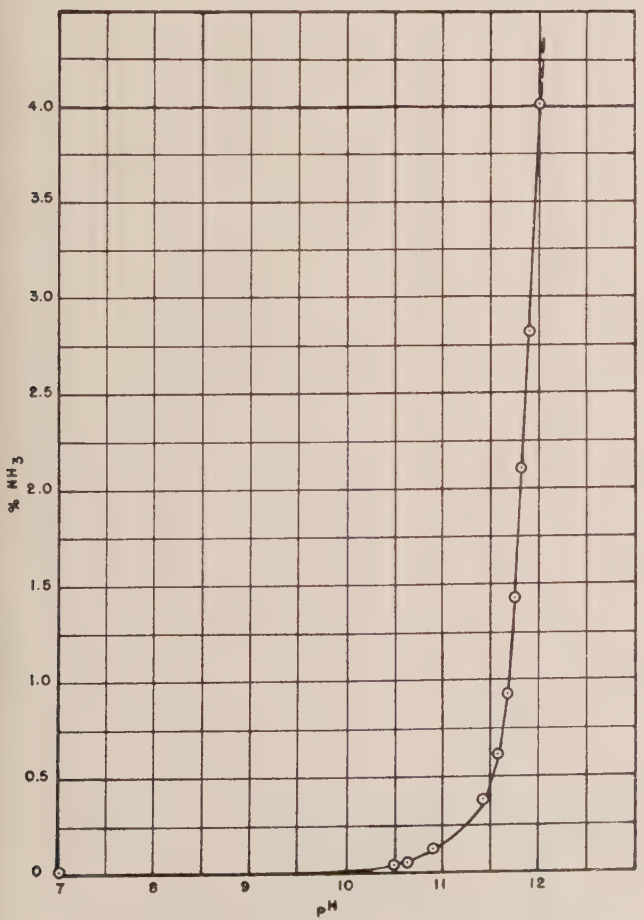

Fig. 1. Variation of pH with per cent NH_3 in solution

Table IV. The Distribution of SO_2 in a 2.82% NH_3 Solution for Various Total SO_2 Concentrations

% Free SO_2	% Total SO_2	% Combined SO_2	% Free SO_2 / % Total SO_2	pH
1.66	6.80	5.14	0.244	6.39
2.26	7.19	4.93	0.315	6.17
2.64	7.56	4.92	0.350	6.12
3.18	8.05	4.87	0.396	5.87
3.69	8.58	4.89	0.430	5.63
4.35	9.31	4.95	0.468	5.27
4.91	9.82	4.91	0.500	4.73
5.77	10.69	4.92	0.541	2.82
6.69	11.56	4.87	0.579	2.47
7.71	12.50	4.79	0.617	2.17
8.87	13.64	4.77	0.650	2.11

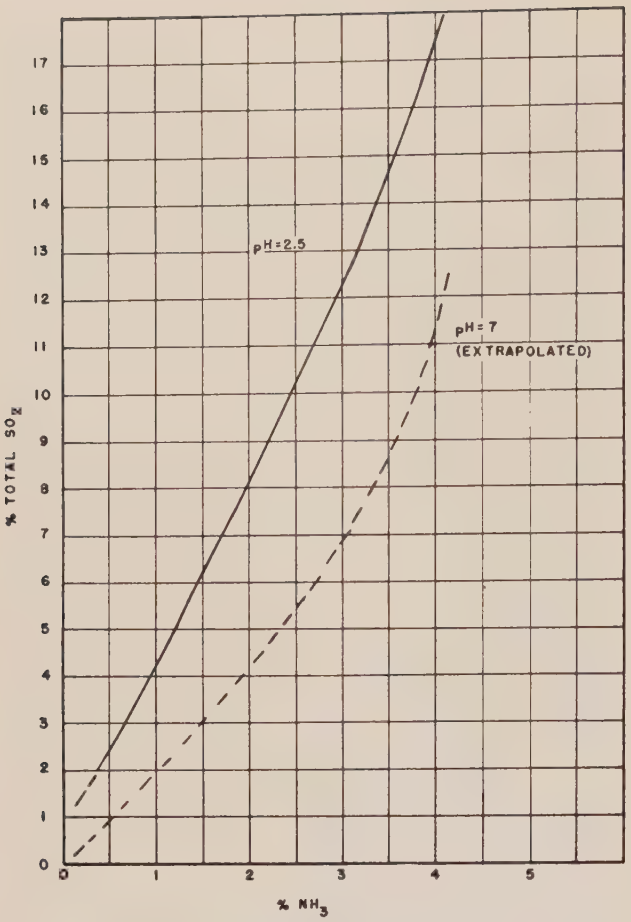

Fig. 3. Composition of solutions to give a constant pH of 7 and 2.5

line to the pump, thereby automatically priming the pump. When the desired amount of water has been collected in the system the pump is started. Water is drawn from the carboy through a porcelain-lined, flow-type pH electrode assembly and an aluminum gas injection system into the pump. The discharge from the pump flows into an aluminum separator. By gravity flow the water leaves the separator and runs down through a packed column that empties into the carboy. This packed column is made of 2-inch aluminum pipe filled with half-inch Berl saddles, and is about 33 inches high.

With the water circulating as described, ammonia is added to the system into the suction line to the pump, i.e., at a point between the pH electrode assembly and the suction port. In so doing the gas-water mixture is first fed to the pump where the gas is reduced to very small bubbles, aiding its absorption. The mixture then flows into the separator in which any undissolved gas collects at the top while the liquid solution flows into the packed column. To be recovered, the gas must bubble through the solution in the carboy and flow countercurrent to the liquid stream through the packed column to the vent.

When the desired concentration of ammonia is reached, this gas is shut off and sulphur dioxide is added to the system in the same manner. Upon completing the preparation of the solution, the valve of the solution outlet is opened and the solution is pumped out of the system.

During the preparation of the solution its pH is read from a Beckman pH meter, model M. The model H-2 meter cannot be used with this system since it cannot be used with a grounded electrode system. The measurement is made by means of a glass electrode and a calomel electrode fitted into the electrode assembly. While the exact concentration of ammonia cannot be determined from pH measurements, it is possible to estimate the rate of absorption from them. To use pH measurement to test SO_2 concentration it is necessary to know the ammonia concentration, therefore a sample of the ammonia solution should be drawn off and tested before SO_2 is added to the system.

Originally a small stainless steel centrifugal pump was incorporated into the apparatus, but this pump vapor locked so easily that the rate of gas feed was greatly limited. To speed up the preparation procedure it was necessary to increase the gas feed rate, so another type of pump was tested. This was a Viking gear pump. It was not made of stainless steel and was therefore subject to corrosion, but its use increased the rate at which solutions could be prepared. Using this pump the SO_2 gas can be injected into the system as rapidly as the fittings on the gas bottle will permit.

CONCLUSIONS AND RECOMMENDATIONS

The analytical procedure described here seems to be satisfactory for testing ammonia-base sulphite pulping solutions. Additional research will show if it can also be applied to spent liquor. One batch of spent liquor was tested with this method with fairly good results, but more tests are needed.

The use of pH as a measurement of NH_3 concentration in preparing pulping liquors did not prove very reliable.

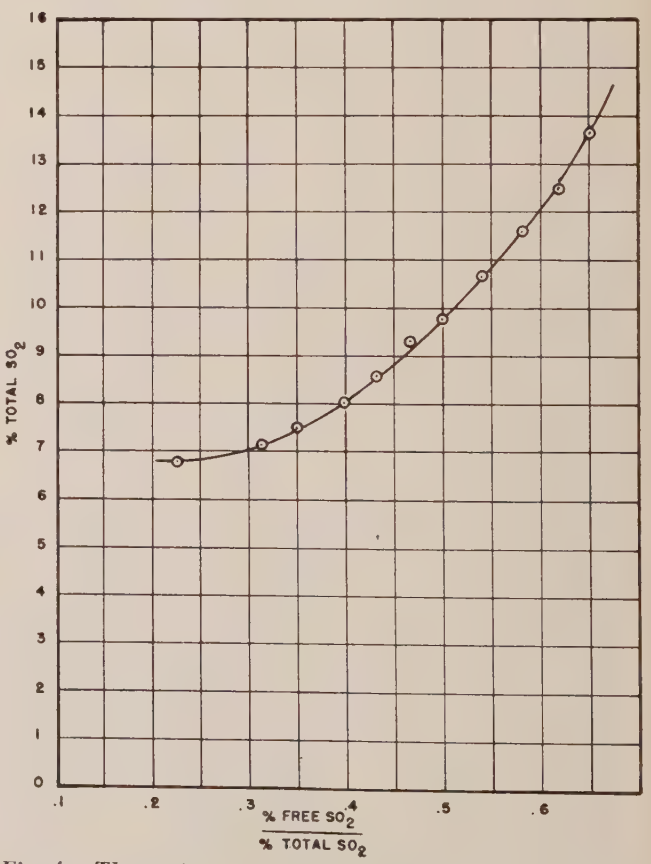

Fig. 4. The variation of the ratio of free SO_2 to total SO_2 with total SO_3 in a solution containing 2.82% NH_3

The use of pH to determine SO_2 concentration in ammonia solutions seems much more promising and can probably be used in preparing most solutions.

Measurements of pH are very sensitive, and any given reading cannot be relied upon too heavily. Temperature changes can have some effect on the readings, but the model M Beckman pH meter is designed to measure accurately at any temperature between 20 and 30°C. Outside of this range the readings must be corrected. Changes in the composition of the tap water used are more serious and are very difficult to compensate. Another variable that affects the readings is a change in the standardization of the pH meter caused by vibration or other means.

Even though the pH readings do not constitute an accurate analysis and must be supplemented by laboratory analyses, the trend of the absorption can be followed readily from these measurements. It will undoubtedly simplify the preparation of solutions by permitting fewer trial-and-error tests.

Examination of other solution variables that might replace pH as a concentration measurement indicates that electrolytic conductivity measurements may offer some promise. Work is now progressing along this line. Another possible approach to the problem could be through metering of water and injected gases. Assuming no losses and constant quality these measurements could give an accurate value for the concentration. The metering method could be incorporated into the present system that has been built for solution preparation.

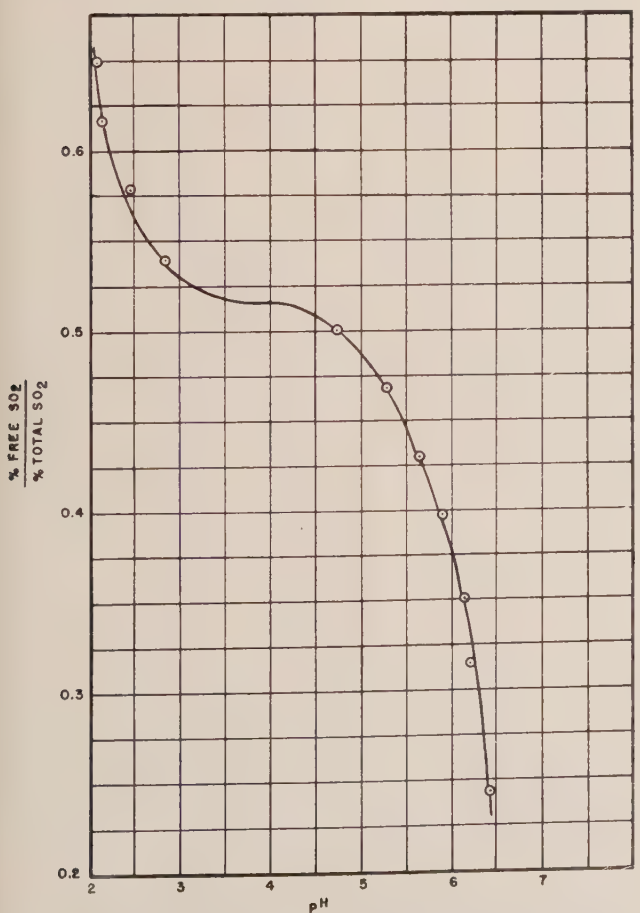

Fig. 5. Variation of the ratio of free SO_2 to total SO_2 with pH in a solution of 2.82% NH_3

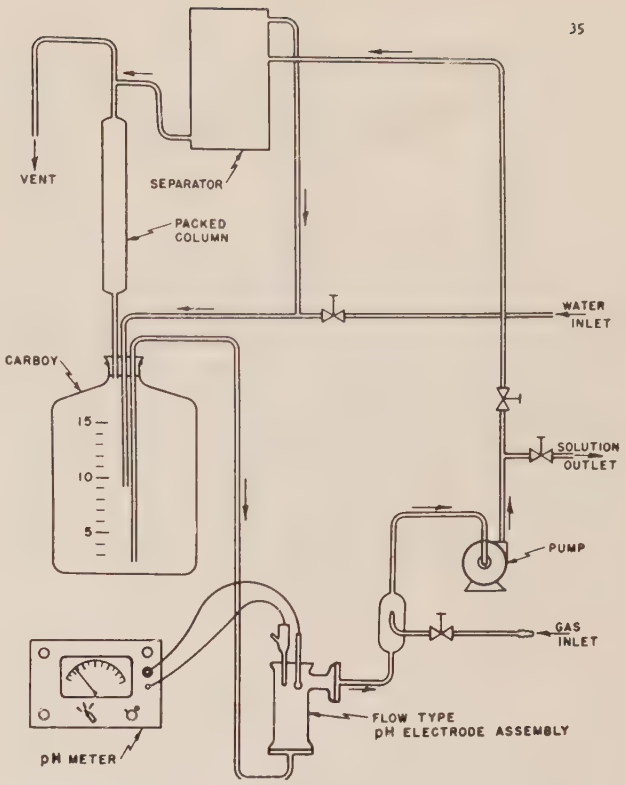

Fig. 6. Flow diagram of system used in preparing ammonia-base sulphite pulping liquid

The apparatus built for preparing solutions has been shown to work satisfactorily. During solution preparation there has been no noticeable loss of gas from the vent, indicating a good absorption efficiency. No serious heating was encountered while preparing solutions in manner described. One possible improvement that could be introduced would be a bypass line for the electrode assembly. This would permit removal of the electrodes for standardization during the preparation process. If neutral or alkaline cooking liquors are desired, it will be necessary to obtain data beyond the range shown in Table III and Fig. 2.

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Distribution of Starch in Clay Coatings

J. WAYNE DAPPEN

A study has been made of methods for quantitatively determining the distribution of the adhesive vehicle in wet laboratory coatings of starch-clay color upon a mechanical pulp-sulphite coating raw stock, the redistribution of the starch during drying, and the distribution of starch in the dry coated sheet. There was little migration of the starch into the base sheet. During rapid air-drying, starch migrated to the top of the coating, thus producing a nonuniform distribution, with less starch at the coating-fiber interface than at the top surface of the coating. The results of this and other studies should give information regarding the dusting, picking, and ink receptivity of coated printing papers.

THE coating of paper with an aqueous dispersion of a pigment and an adhesive is an important phase of the paper industry. In the coating process a multitude of complex variables must be correlated and/or controlled for successful operation. The influence of the important physical, chemical, and colloidal properties of the raw materials (pigments, adhesives, and raw stocks) upon the color behavior and paper coating properties has been the subject of widespread investigation and much speculation.

The primary purpose of the adhesive is to bind the pigment particles together and to anchor the coating to the surface of the raw stock. The difficulties resulting from defective bonding between pigment particles (known as dusting) and between the coating and raw stock (known as picking or flaking) are very familiar. Such difficulties (*1, 2*) are generally attributed to a low adhesive to pigment ratio within the coating or at the surface of the fibrous body stock. These concepts are based largely on speculation or empirical experiments and are not supported by sufficient evidence to warrant their acceptance. Work in this field has been and is hampered by analytical methods which are admittedly not the best and leave much to be desired.

A survey of the literature reveals that several investigators (*3–5*) have noted qualitatively a penetration of the adhesive from the coating into the raw stock. However, no experimental data have been reported on the amount of adhesive which penetrates the body stock or on the final distribution of the adhesive in the coating. The primary purpose of this investigation was to develop methods for quantitatively determining the redistribution of the adhesive vehicle of the coating and to attempt to establish the final distribution of the adhesive in the coating. Such a study should be of fundamental importance in establishing an understanding of dusting, picking, and ink receptivity of coated papers.

MATERIALS

The clay employed in the investigation was a Georgia secondary kaolinite and was representative of a grade widely used in the coating industry. The clay contained a free water content of 0.75% as determined at 105°C. and a combined water content of 13.5% as determined at 800°C.

The modified starches used in the coating industry vary widely in their properties, which depend largely upon the method and degree of treatment. Two representative starches were used and were selected for their low ash content. Starch A was a relatively fluid dextrinized starch and starch B was a relatively viscous dextrinized starch; each had an ash content of 0.17%. The starches were dispersed by cooking 1 part of starch with 3 parts of water for 15 minutes at 95°C.

The raw stock employed was a groundwood-sulphite sheet suitable for coating; it had the following properties:

Basis weight (25 × 40—500), lb.	37.2
Caliper, mils	3.2
Gurley porosity, sec./100 cc.	38
Bekk smoothness, sec.	
Felt	38
Wire	31
TAPPI size, sec.	
Felt	30
Wire	29
Fluorescent size, sec.	
Felt	36
Wire	35
Ash content, %	5.1

The same raw stock was used throughout the investigation.

Preparation of Coating Colors

Clay slips which contained 60% solids and 0.4% dispersing agent (Quadrafos or $Na_6P_4O_{13}$) on the weight of the clay were prepared as follows. The required amounts of distilled water, dispersing agent, and clay were placed in a 1-liter porcelain ball mill jar which contained fifty 0.75-inch stainless steel balls. The jar was sealed and rotated at 90 r.p.m. for 1 hour. The required amount of a 25% starch solution was then accurately weighed into the clay slip to give the desired ratio of starch to clay. If necessary, the final weight of the color was adjusted with distilled water. The color was thoroughly mixed and then passed through a laboratory hand homogenizer before using.

METHODS

Determination of the Redistribution of the Adhesive Vehicle

In order to quantitatively investigate the redistribution of the fluid phase of the coating into the raw stock, coatings were applied to the raw stock by means of a 1.5-mil Bird bar; after given intervals of time, the wet coatings were removed from the paper with a scraper, consisting of a 1.75 by 8-inch piece of 8-mil spring steel mounted in a wooden handle for rigidity.

The wet coatings which had been removed from the raw stock were analyzed for total solids, clay, and

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starch content as follows: A representative sample of the coating was quickly transferred with the aid of a spatula to a porcelain crucible which had been tared in a weighing bottle. The sample was weighed and the total solids content of the coating determined by oven-drying at 105°C. for 15 hours. The sample was then ignited in the crucible for 2 hours at 800°C., returned to the weighing bottle, cooled, and again weighed. The weight of oven-dry clay was calculated from the weight of the ignited residue since the ignition loss of the clay was known and the ash content of the starch and dispersing agent could be neglected without causing a serious error. The starch content of the sample was determined as the difference in weight of the oven-dry sample and the oven-dry clay.

The evaporation of water at the coating-air interface was determined by repeating the procedure with coatings applied on clean glass plates. Since the rate of evaporation would depend on the temperature and humidity of the room, these variables were kept constant by carrying out all coating and scraping procedures in a room maintained at 50% R. H. and 73°F.

The accuracy of the method for determining the composition of the coatings was checked by analyzing coating colors of known composition. The analyses for the total solids content and the percentage of starch on the oven-dry weight of clay indicated that the accuracy of the method was within ±1% of the theoretical composition of the coating color.

Visual observations indicated that the scraper was very effective in removing the wet coating from the raw stock and glass. The amount of coating remaining in and/or on the raw stock after scraping was found to average approximately 1.5 pounds per ream (25 × 40—500).

Distribution of Starch in Filter Cakes Formed from Coating Colors

The coating color was filtered at 100 p.s.i. in a pressure filter, using Whatman No. 1 filter paper as a filter base. The filtration was not carried to completion but was stopped when a filter cake approximately 0.25 inch in thickness had been formed. The excess color was poured from the filter and the cake was removed. After removing the filter paper from the cake, the cake was placed bottom side down on a glass plate and was cut in half with a razor blade. One half of the wet filter cake was sectioned from top to bottom by removing successive layers of the cake with the straight edge of a spatula. The layers were placed in separate porcelain crucibles and were analyzed for clay, starch, and solids content. The distribution of starch through the filter cake was represented graphically by plotting the percentage of starch in the section against the percentage of oven-dry filter cake by weight. The percentage of starch (clay basis) for each layer was plotted against the percentage by weight of the dry filter cake which lay above the midpoint of the layer.

The other half of the filter cake was placed on a 10-mesh wire screen bottom side down and oven-dried at 105°C. After drying, the edges of the cake were removed and the remaining sample was sectioned from top to bottom by removing successive layers with a clean file. The filings of each layer were quantitatively collected and placed in a porcelain crucible for analysis.

Distribution of Starch in Coatings on Glass

Coatings were applied on glass plates with Bird bars and were allowed to air-dry at room temperature or were oven-dried at 90°C. without forced circulation.

The distribution of the starch in the coatings was determined by sectioning the coatings according to the following procedure. Approximately a 5 by 5-inch area of the coating was ruled off and the surrounding coating was removed from the glass with a razor blade. The remaining coating was then sectioned by gently scraping the entire surface of the coating with a new razor blade held normal to the surface of the coating. In order to obtain uniform abrasion, the direction of scraping was changed periodically. Having passed over the entire coating by scraping in one direction, the direction of scraping was rotated 45°. When a sufficient amount of dust had been collected for analysis, it was quantitatively transferred to a tared porcelain crucible and the process repeated. By such a procedure it was possible to divide the coating into five to eight layers. The clay and starch content of each layer was determined and the ratio of starch to clay plotted against the percentage of coating by weight.

Distribution of Starch in Coatings on Paper

Briefly, the raw stock was coated by pulling the paper at a uniform rate under a Bird bar which was kept stationary and held with a uniform pressure against the paper. The coating color was added continuously from a funnel directly ahead of the bar which smoothed and metered the color onto the base paper. The coated paper was allowed to air-dry and was conditioned at 50% R. H. and 73°F. before using.

After investigating several possibilities, the following technique was used to section the coatings on paper in order to study the starch distribution. By means of an erasure tester (*6*) which was equipped with a Taber No. CS 10 F eraser, a series of samples from the same lot of coated paper was prepared in which the abrasion of the coating varied from no erasure to nearly complete removal. A 2.5 by 2.5-inch square was then accurately cut from the abraded area of each sample for the determination of the starch and clay content of the coating remaining on the paper.

The starch was extracted from the samples and determined photocolorimetrically according to the following procedure: The sample was cut into $^1/_2$ inch squares and placed in a 40-ml. centrifuge tube containing 30 ml. of distilled water. The tube was heated for 15 minutes with frequent stirring in a boiling water bath. After cooling to room temperature, the clay was coagulated by adding 0.5 ml. of concentrated hydrochloric acid dropwise with stirring, and the suspended material was centrifuged. The extract was carefully decanted into a volumetric flask and the residue was extracted a second and third time with 30-ml. portions of hot water for 5 minutes. The residue was then treated with 5 ml. of cold concentrated hydrochloric acid and stirred vigorously to disintegrate the base paper. After 30 seconds the acid was diluted with 25 ml. of distilled water, stirred, and centrifuged. The acid extract was decanted into the volumetric flask and the acid extraction was repeated. Following the second acid extraction, the residue was given a final extraction with 25 ml. of cold distilled water. The combined extracts

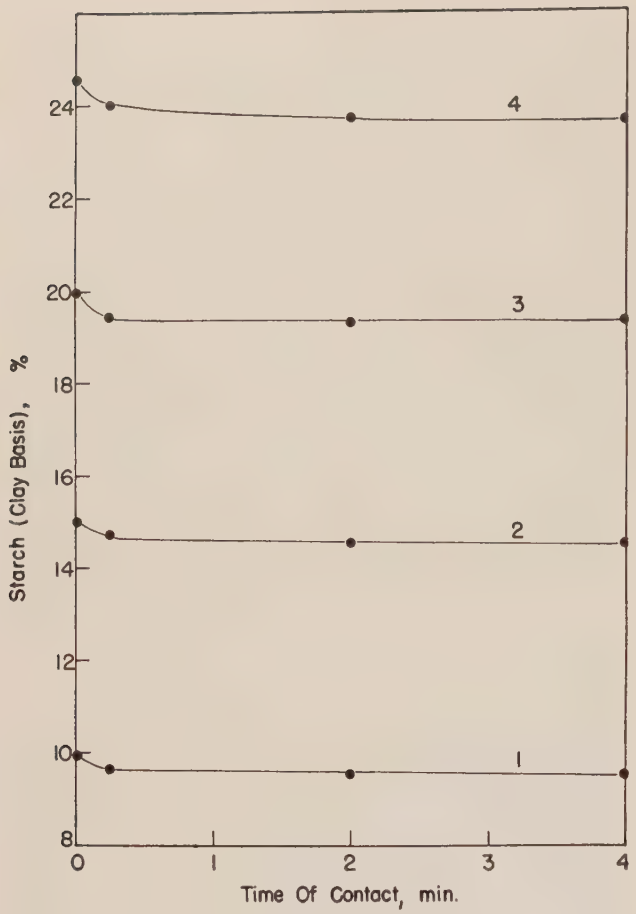

Fig. 1. Effect of time of contact on the starch content of coatings

were diluted to volume with distilled water, thoroughly mixed, and centrifuged to remove any clay or fiber carried over during the decantations. In order to increase the concentration of starch in the extract from samples containing small quantities of starch, the volumes of liquid used in the above procedure were reduced so that the total volume of extract did not exceed 100 ml.

The above method was developed by Browning, Baker, and Bublitz (*7*).

An appropriate aliquot of the centrifuged extract was transferred by means of a pipet to a 100-ml. volumetric flask, and the required volume of a standard iodine solution (equivalent to 7.50 mg. of iodine) was added from a buret. The solution was diluted to volume with distilled water, thoroughly mixed, and allowed to stand 15 minutes before making transmittance measurements. The transmittance of the starch-iodine suspension was determined with the apparatus described by Simerl and Browning (*8*), using 10.0-mm. absorption cells and a 75-p.p.m. iodine solution as a standard. The concentration of starch was determined from a calibration curve and the total amount of starch in the sample was calculated. The calibration curve was prepared by subjecting known amounts of dispersed starch (same type as in the coatings) plus 6.25 square inches of the raw stock to the procedure just described. The transmittance readings were plotted against the known concentration of starch on semilog graph paper.

The clay content of the sample was determined as follows. The extracted residue and the material removed from the combined extracts by centrifuging were quantitatively transferred with the aid of filter paper to a tared porcelain crucible. The material was dried, charred, and ignited for 2 hours at 800°C. Since both the ignition loss of the clay and the ash content of the raw stock had been determined, it was possible to calculate the oven-dry weight of clay in the sample.

The distribution of starch in the coating was determined in the following manner: The starch and clay content of the samples were plotted, using the weight of starch as the ordinate and the weight of clay as the abscissa. The slope of the curve at any point represents the ratio of starch to clay at the corresponding point within the coating. The distribution of starch through the coating was determined by graphically differentiating the starch-clay curve and plotting the ratio of starch to clay against the corresponding percentage of the coating by weight.

RESULTS

Redistribution of the Adhesive Vehicle

When a coating color is applied to the porous surface of a paper, there is a redistribution of the fluid phase of the coating into the raw stock as a result of capillary forces. This redistribution was investigated by applying coatings [25 lb. per ream (25 × 40—500) air-dry] on paper and glass with a 1.5-mil Bird bar; after given intervals of time, the wet coatings were removed and their composition was determined. The coating colors employed in the study contained 46.8% total solids and varying percentages of starch B on the weight of the clay. The analyses of the wet coatings are tabulated in Table I and are shown in Figs. 1 and 2. (The numbers 1 to 4 in these figures refer to the coating colors in Table I.)

Of considerable interest was the observation that the average loss of starch from the coating to the base paper was small. This loss, after 4 minutes' contact with the base paper, was found to be 3 to 4% of the total starch content of the initial coating. In general, the most significant change in the starch content of the wet coating was found to occur within 15 seconds' contact with the base paper; there was only a slight change after 1 minute (Fig. 1). It should be emphasized that these results are average values for the removed coatings and that the actual loss of starch from a layer immediately adjacent to the paper may be larger.

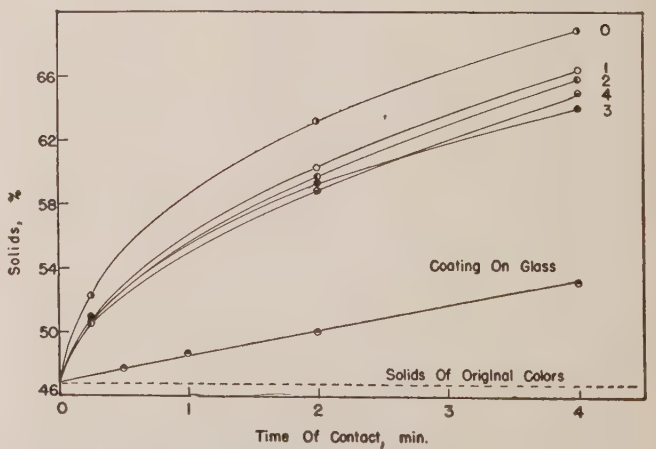

Fig. 2. Change in solids content of coatings as a result of penetration and evaporation

The solids content of wet coatings on paper will increase with time because of penetration of the fluid phase of the coating into the raw stock and because of the evaporation of water at the coating-air interface. Obviously, coatings on glass can increase in solids content only by evaporation of water and, for all practical purposes, the rate of evaporation was found to be independent of the adhesive content of the coating. The rate of change of solids content of the coatings at any time is represented by the instantaneous slope of the solids-time curves (Fig. 2). This illustrates the fact that, for coatings on paper, the initial rate of change of the solids content was large but it decreased rapidly and approached that for coatings on glass, which was practically constant during the time range studied. The difference in the slopes of the curves for coatings on paper and glass should be related to the change in the solids content of the coatings resulting from the penetration of the fluid phase into the raw stock. This means that, for coatings on paper, there was little penetration of the fluid phase into the raw stock after 2 minutes, and the continued increase in solids content of the coating thereafter was caused primarily by evaporation.

From the analyses of the coatings (Table I), the percentages of water lost from the coatings on glass and paper, after given intervals of time, were calculated on a relative basis, using the following assumptions: (1) the initial weights of the coatings on glass and paper were equal—i.e., equal weights of coating color covered equal areas on glass and paper. (2) A representative sample of the coatings was removed quantitatively from the glass or paper, and the amount of clay re-

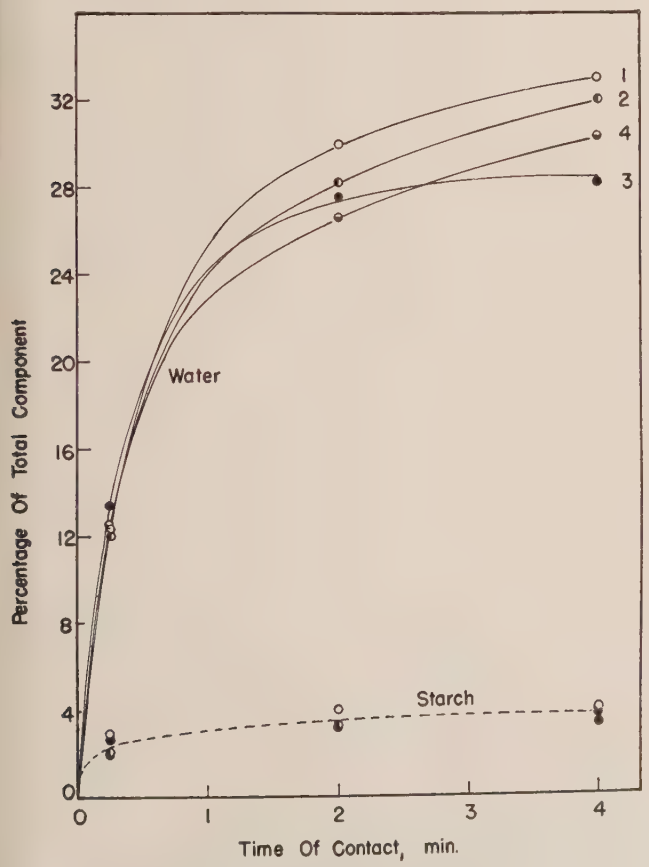

Fig. 3. Percentages of total water or starch lost from coatings by penetration

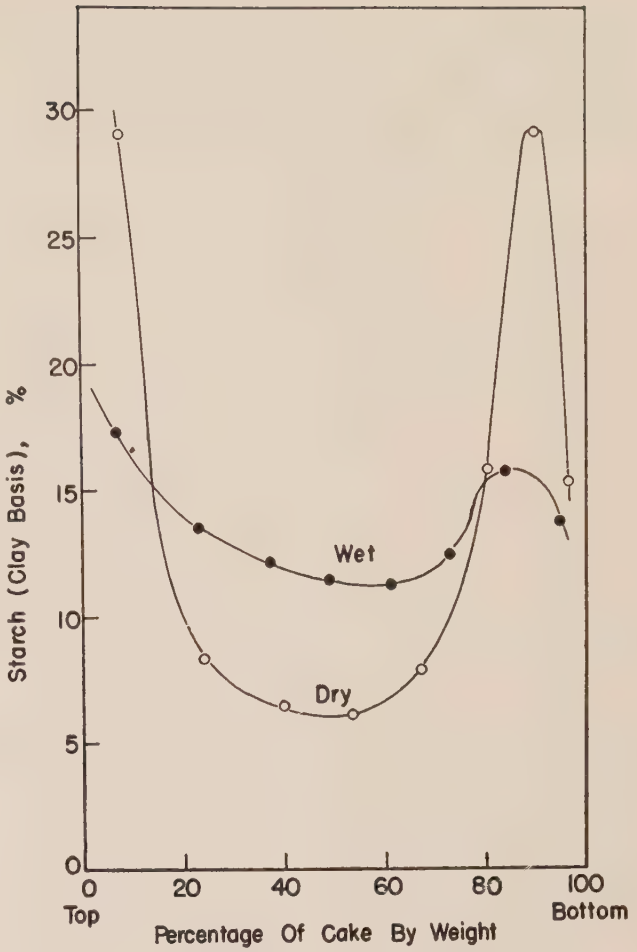

Fig. 4. Distribution of starch in filter cake

covered per unit area was equal to that of the initial coating. For example, if the initial coating consisted of 100 grams of coating color, the amounts of clay,

Table I. Composition of Wet Coatings Which Were Removed from the Raw Stock After Given Intervals of Time

Coating color	*Raw stock*	*Time, min.*	*Solids, %*	*Starch, %*
0	..	0	46.8	..
0	A	1/4	52.3	..
0	A	2	63.2	..
0	A	4	68.9	..
1	..	0	46.8	9.9
1	Glass	1/2	47.8	9.9
1	A	1/4	50.7	9.6
1	A	2	60.3	9.5
1	A	4	66.4	9.5
2	..	0	46.8	15.0
2	Glass	1	48.7	14.9
2	A	1/4	50.6	14.7
2	A	2	59.8	14.5
2	A	4	65.9	14.4
3	..	0	46.8	19.9
3	Glass	2	50.1	19.9
3	A	1/4	51.0	19.4
3	A	2	59.3	19.3
3	A	4	64.0	19.3
4	..	0	46.8	24.5
4	Glass	4	53.2	24.4
4	A	1/4	50.7	24.0
4	A	2	58.9	23.7
4	A	4	65.0	23.6

starch, and water in the coating were calculated from the known solids and starch content of the color. In a similar manner, the amounts of starch and water pres-

ent in the coatings scraped from the glass and paper after given intervals of time were calculated, since it was assumed that the amount of clay was equal to the clay content of the initial coating. The amount of water lost from the initial coating was determined by differ-

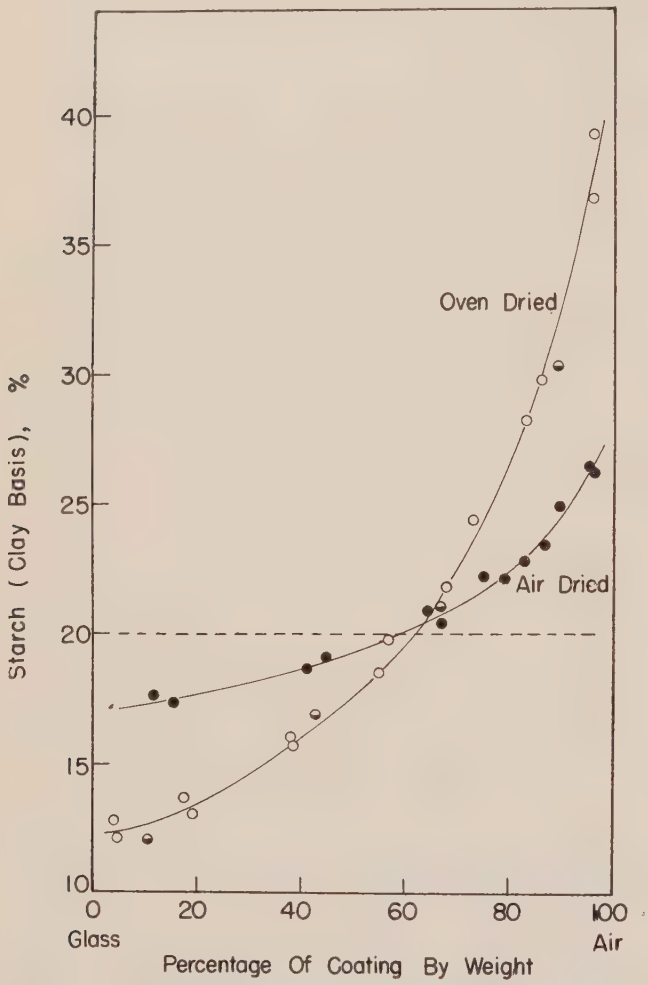

Fig. 5. Distribution of starch in coatings on glass. Coating weight, 92 lb. (25 × 40—500)

ence, and the percentage loss of initial water calculated in each case.

From the previous calculations, the percentage of initial water which had penetrated the raw stock was determined as the difference in the percentages of initial water lost from coatings on paper and glass in the same time interval. This assumes that the evaporation loss from coatings on paper and glass are equal, which follows from the previous assumption that equal weights of coating color will cover equal areas on glass and paper since, in this case, the evaporation loss is primarily dependent on the surface area.

The results of the calculations on the percentage of total water lost by penetration of the raw stock are shown as a function of time in Fig. 3. (The numbers 1 to 4 in the figure refer to the coating colors in Table I.)

The percentage of total starch which was lost from the initial coating by penetration of the raw stock was calculated from the data in Table I in a manner similar to that described for the water. The results of the calculations for the penetration loss of starch are shown in Fig. 3.

An examination of the curves in Fig. 3 shows that 28 to 33% of the total water and 3 to 4% of the total starch in the initial coating had been lost by penetration after 2 to 4 minutes' contact with the base paper. This clearly indicates that the water and starch do not penetrate the raw stock in the same proportions as represented in the original color. Since the water penetrated in a much larger proportion than the starch, the dispersed starch must have been removed from the aqueous phase by filtration or sorption as penetration progressed. In general, the penetration losses of starch and water tend to decrease slightly as the adhesive content of the coatings increases. This is probably due to the increase in viscosity of the coating color and/or the aqueous vehicle, the increase in the number of starch particles which are removed from the suspension by filtration and/or sorption, and the consequent increase in the resistance to flow. The data clearly indicate that little penetration occurs in the last 2 minutes during which the coating was in contact with the raw stock.

Some of the possible reasons for the greater penetration of the raw stock by water than by starch were investigated. The influence of the clay particles was studied indirectly by carrying out experiments similar

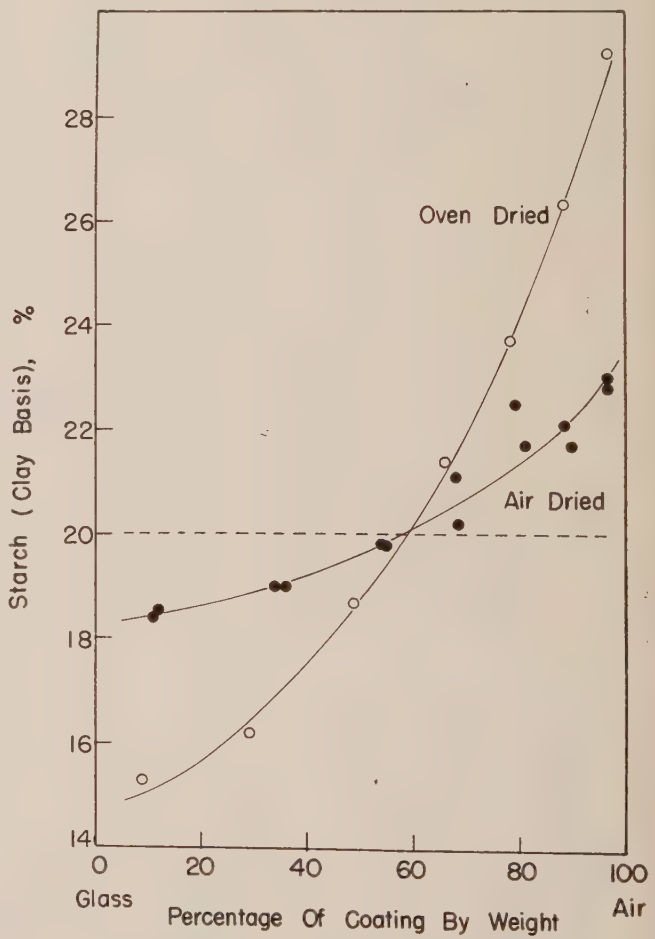

Fig. 6. Distribution of starch in coatings on glass. Coating weight, 47 lb. (25 × 40—500)

to those just described with a 15% starch solution as the coating composition which was applied to glass and paper with a 1.5-mil Bird bar.

In this case, the analyses were carried out on a constant area basis, since no component of the coating

(such as clay) could be assumed to remain constant. The results of the investigation indicated that the percentage of total water and total starch which remained with the raw stock after scraping was approximately 30 and 13%, respectively. Therefore, the phenomenon was not completely dependent upon the presence of clay, although the penetration of starch was considerably smaller in the coating color. The smaller penetration of starch in the coating colors might be due to a partial plugging of the pores near the surface of the paper by clay particles.

Although little is known about the particle size of the dispersed starch, it is undoubtedly very heterogeneous and varies from true molecular dispersion to fragments of undispersed starch granules. A sample of diluted starch solution viewed with a phase microscope at 920× revealed numerous particles of approximately 0.5 micron in diameter which exhibited Brownian movement. Therefore, some of the poorly dispersed starch particles may actually be larger than the pores in the raw stock, whereas the more completely dispersed starch may not pass through the capillaries because of adsorption or electrokinetic phenomena. The possibility of adsorption is not too unlikely in view of the fact that the amylose fraction of starch is selectively adsorbed on cellulose.

The possibility of selective adsorption of the starch by the clay, as well as the mechanical retention of the dispersed starch by the clay particles, was also investigated. Coating colors and starch solutions which possessed the same ratio of starch to water were prepared and aliquots of each were pressure filtered, or supercentrifuged. The ratio of starch to water in the filtrates and centrifugates was determined and compared with the ratio of the original solution or color. The results of the investigation indicated that there was no appreciable selective adsorption of starch by the clay because the ratios of starch to water in the centrifugates of the coating colors and starch solutions were the same. A portion of the starch was mechanically retained with the clay during filtration. In the latter case, if 30% of

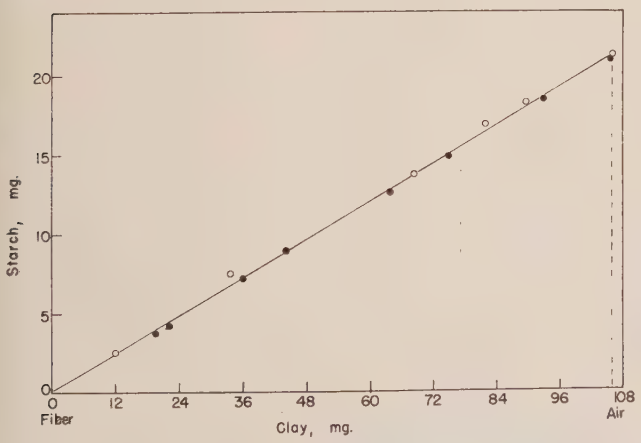

Fig. 7. Starch-clay curve for air-dried coated paper. Coating weight, 23 lb. (25 × 40—500)

the total water of the coating color had passed the filter, approximately 15 to 20% of the total starch flowed with it. Thus, although the starch and water migrate more nearly in the same proportions during filtration than when a starch solution is spread on paper, it seems very likely that mechanical retention of starch at the paper surface is an important restricting factor in the migration of starch into the raw stock.

The effect of the moisture content of the raw stock on the redistribution of the adhesive vehicle of wet clay

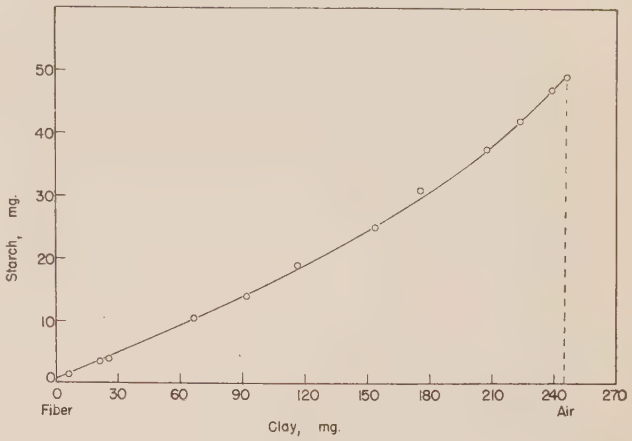

Fig. 8. Starch-clay curve for coated paper dried with hot air blast. Coating weight, 53 lb. (25 × 40—500)

coatings (47% solids and 20% starch B) was investigated by carrying out similar experiments at different humidities. The moisture content of the raw stock at 50% R. H. and 73°F. was 6.1%, and the percentage of total water and total starch lost by penetration from the initial coating after 2 minutes was 27.5 and 3.0%, respectively. The moisture content of the raw stock at 85% R. H. and 80°C. was 13.1% and the penetration loss of water and starch was 19 and 2.5%, respectively. The smaller penetration losses found with the raw stocks of higher moisture content might be due to a change in the capillary structure of the paper with a change in the moisture content. In general, the air permeability of paper decreases with increasing relative humidity, which is probably due to a decrease in pore size resulting from a slight increase in the width of the fibers at a higher moisture content. Also, the raw stock of lower moisture content might be expected to absorb a larger amount of the fluid phase penetrating the capillaries.

Distribution of Starch in Filter Cakes Formed from Coating Colors

When a coating is applied to the raw stock, part of the fluid phase of the coating penetrates into the paper. Because of this fluid redistribution, a compacted layer of pigment particles is deposited at the surface of the raw stock, and the solids concentration of this compacted layer is higher than that of the layer of original coating color superimposed on it. Obviously, the formation of this compacted layer of pigment particles is analogous to the formation of a filter cake during filtration. Since previous work has indicated that part of the starch is mechanically retained with the clay during the redistribution of the adhesive vehicle, the distribution of starch in filter cakes formed from coating colors was investigated. It was hoped that a better knowledge of some of the principles involved in the redistribution of the adhesive during the coating operation might be obtained from the trends found for the adhesive distribution in the filter cake.

From a coating color of 48.5% solids and 20% starch A on the weight of the clay, a filter cake was formed, sectioned, and analyzed for starch and clay as previously described. The distribution of starch in the wet and oven-dry filter cake is illustrated graphically in Fig. 4.

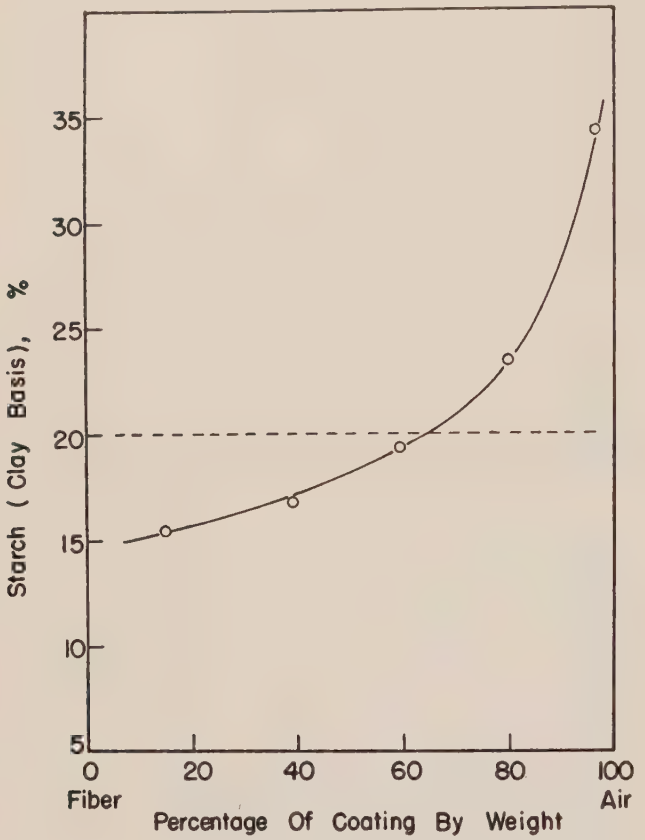

Fig. 9. Distribution of starch in coated paper dried with hot air blast

The ratio of starch to clay in the wet filter cake decreased from the top to a minimum near the center of the cake and then increased to a maximum near the bottom of the cake.

The starch distribution in the wet filter cake may be explained by the variations in pore space and mechanically retained starch in the cake from top to bottom. The pore space in the filter cake decreased from top to bottom, because of the pressure gradient through the cake during filtration. Theoretically, the pore space between the clay particles at the very top of the cake should approach that of the original coating color since filtration was stopped before the cake filtered dry. For some distance from the top of the cake, the ratio of starch to clay will decrease because the clay particles are closer together and the proportion of aqueous starch solution contained in the pore spaces between the clay has been decreased. As the clay particles become closer and closer together, they begin to filter poorly dispersed starch particles. At some point within the cake, the decrease in starch due to a smaller pore volume is compensated by the starch filtered out between the clay particles. From this point, the starch which is filtered out is more than sufficient to account for the decreased pore volume; and the ratio of starch to clay increases. The maximum in the distribution curve near the bottom is probably due to the fact that a thin layer of clay may be required on the filter base before a significant amount of starch is mechanically retained in the filter cake.

The distribution of starch in the filter cake was definitely modified upon oven-drying (Fig. 4). In general, the concentration of starch at the top and near the bottom of the cake increased, whereas the concentration of the starch in the center of the cake decreased. The results demonstrate that, upon oven-drying, a part of the starch in the center of the cake migrated with the free water toward the surfaces and was deposited when the water passed into the vapor phase. This investigation suggests that the adhesive in pigment coatings may be redistributed not only by penetration of the paper but also by migration with the free water during drying.

Distribution of Starch in Coatings on Glass

The study of the migration of the adhesive upon drying was extended to thinner films which more nearly approached the thickness of commercial coatings. Drawdowns of a coating color (48.6% solids and 20% starch A) were made on clean glass plates with 3 and 6-mil Bird bars which gave coating weights of approximately 46 and 92 pounds per ream, respectively. The wet coatings were either air-dried at room temperature or oven-dried at 90°C. without forced circulation

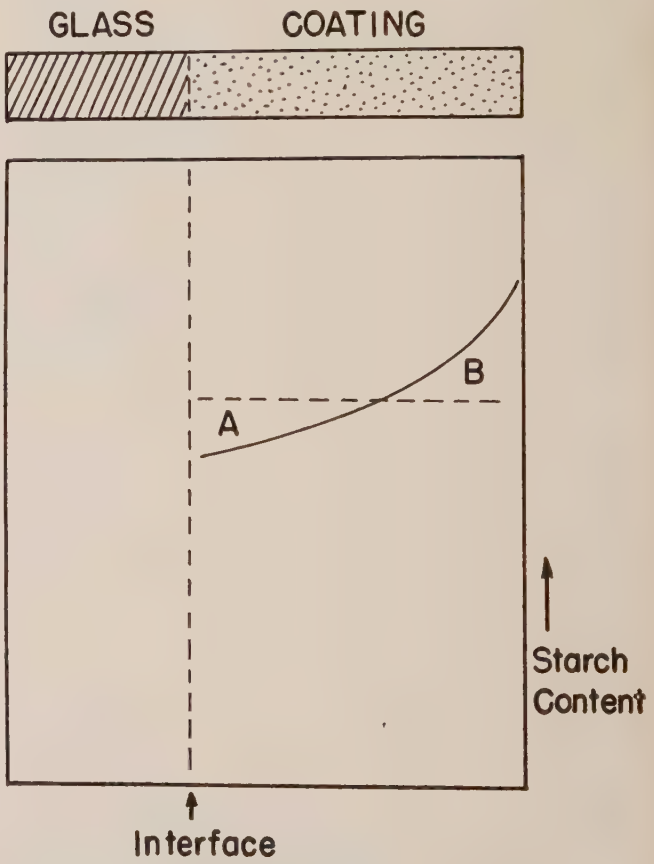

Fig. 10. Schematic graph of starch distribution in coatings on glass

and then sectioned and analyzed for starch and clay. The results of the distribution study are shown graphically in Figs. 5 and 6.

The horizontal dotted lines in Figs. 5 and 6 represent the percentage of starch on the weight of the clay in the

original coating color which would remain constant throughout the coating if no redistribution of the starch occurred on drying. An examination of the solid-line curves shows that, in all cases, the percentage of starch increases continuously from the glass to the air interface in the coatings. This clearly indicates that a definite migration of the adhesive toward the air interface occurred upon drying. A more pronounced migration of the adhesive was found in the oven-dried coatings, as well as in the heavier coatings.

The migration of the adhesive toward the air interface of the coating during drying might be explained by the following hypothesis of the drying mechanism. During the first stage of drying, capillary forces are not involved, since the pore spaces are filled with liquid and no liquid-air menisci are present. In this stage, the surface of the coating possesses a continuous liquid film which imparts a characteristic gloss to the wet coating.

When water begins to evaporate at the surface of the coating, the dispersed pigment particles move closer together and the solids concentration of the top portion of the coating increases. This compaction of the pigment particles continues down into the coating, and the liquid film at the surface remains continuous as long as liquid can be displaced from the body of the

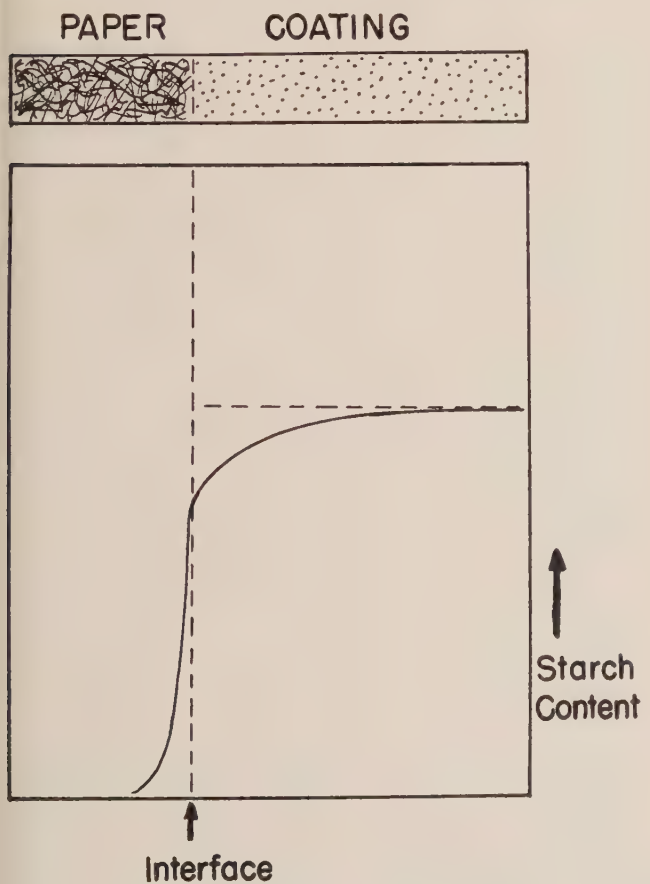

Fig. 11. Schematic graph of starch distribution in coated paper

coating and supplied to the surface at a rate equal to the rate of evaporation. The starch which is carried in the liquid vehicle toward the surface is deposited when the water passes into the vapor phase.

The depth to which this compacted layer of pigment particles extends from the surface into the body of the coating is not known. However, a moisture gradient would be established in the coating and water would tend to diffuse toward the top surface. It is also possible that any tendency toward compaction of the pigment particles near the surface of the coating may be transmitted to a certain degree throughout the coating as a result of balanced forces of attraction and repulsion existing between the dispersed particles.

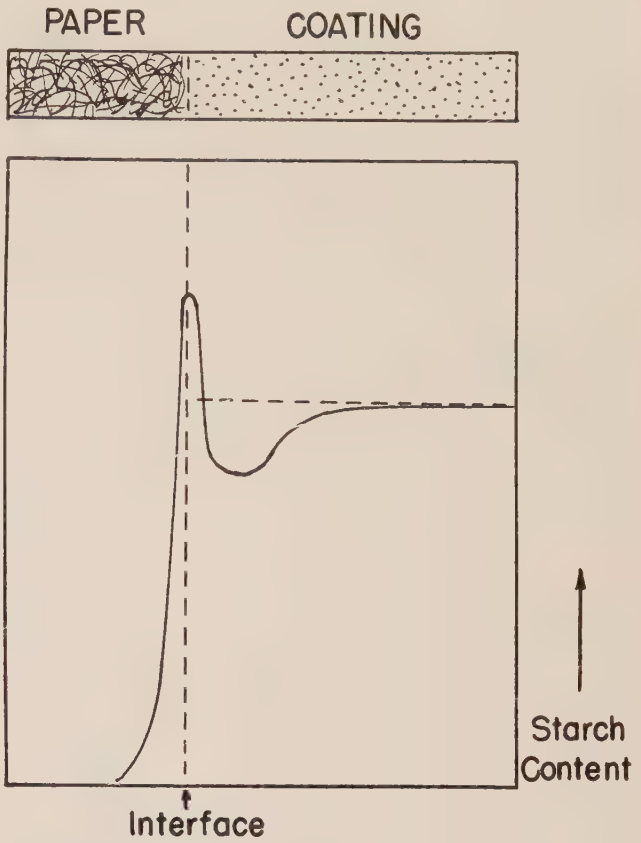

Fig. 12. Schematic graph of starch distribution in coated paper

When the rate of supply of liquid to the surface becomes less than the rate of evaporation, the zone of evaporation must retreat into the coating to a position where the two rates are equal. When this occurs, the continuous liquid film at the surface of the coating is disrupted and the gloss of the coating is lost. At this point, capillary forces come into play since liquid-air menisci are formed in the capillaries and liquid is drawn from the interior of the coating to the zone of evaporation by capillary forces. These forces may draw liquid from zones of the coating which are not compacted and in which the pigment particles are capable of moving closer together.

Oven-drying the coatings produced a more pronounced migration of the adhesive toward the air interface than air-drying at room temperature. This shows that the higher temperature must have increased the mobility of the fluid phase to a greater extent than the rate of evaporation, and a larger proportion of the fluid phase of the coating was evaporated at or near the surface of the coating at the higher temperature.

The more pronounced migration observed in the heavier weight coatings is believed to be due primarily

to the proportionally larger amounts of water and starch per unit area. In other words, more water has to be evaporated per unit area from the heavier coatings and, hence, carries a larger amount of starch toward the air interface.

Distribution of Starch in Coatings on Paper

The previous work has demonstrated that, in the coating operation, the starch adhesive may be redistributed as a result of the penetration of the raw stock and/or the migration with the aqueous vehicle during drying. The next phase of the investigation deals with the distribution of starch in coated paper and employs the methods and techniques previously described.

Specimens from the same lot of air-dried laboratory

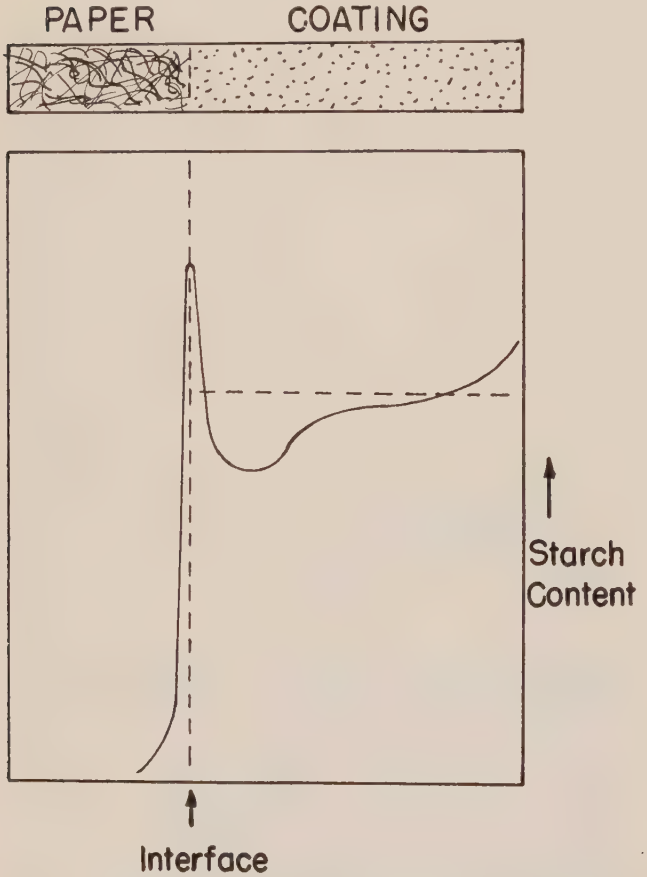

Fig. 13. Schematic graph of starch distribution in coated paper

coated paper, which contained 23 pounds per ream of coating, were abraded to varying degrees by the erasing technique, and the amounts of starch and clay remaining on a given area of each specimen were determined. The results of the analyses were plotted to form the starch-clay curve in Fig. 7.

The linear curve obtained from the starch and clay analyses indicates that the ratio of starch to clay was surprisingly uniform throughout the coating, since the slope of the curve represents the ratio of starch to clay at the corresponding point within the coating. The slope of the curve was found to represent a starch: clay ratio of 0.20, which is in good agreement with the 20% of starch on the weight of the clay in the original color.

In general, approximately 50% of the coating could be removed very uniformly by the erasing technique. Since a large part of the coating could be removed without essentially changing the ratio of starch to clay in the coating remaining on the raw stock, the ratio of the removed coating must have been the same as the original coating color. The surface of the raw stock must be considered to be a series of hills and valleys, so that the coating remaining on the most abraded samples was not continuous but very spotty with numerous small areas of fibers showing. If there was a penetration of adhesive into the paper from a layer of clay very close to the fiber surface, either the layer deficient in adhesive was not removed on erasure or the adhesive penetrated into the paper such a short distance that it was also removed. Hence, the ratio of starch to clay remained essentially constant for the coating retained by the abraded samples.

Upon extrapolation of the curve to zero clay, the curve either passes through the origin or intercepts the starch axis close to the origin. The latter case would indicate that the starch had penetrated the raw stock beyond the point of the clay. Although the accuracy of the method does not permit evaluation of the exact intercept, the results indicate that the penetration of the starch into the raw stock was small. It is very unlikely that the extrapolated curves might intercept the clay axis, since this would indicate that the clay had penetrated beyond the point of the starch.

An attempt was made to alter the distribution of the adhesive in the coating in order to determine whether the techniques and methods would detect a nonuniform distribution of the adhesive. To accomplish this, a heavier weight coating was applied to the raw stock and the wet coating was dried from the coating side with a hot air blast which was obtained by passing compressed air through a coil of copper tubing heated with a Bunsen burner. The dried coated samples were conditioned at 50% R. H. and 73°F., abraded by the erasing technique, and analyzed for starch and clay. The results are shown in Figs. 8 and 9.

The starch-clay curve definitely departs from linearity and indicates a nonuniform distribution of starch in the coating. The ratio of starch to clay increases continuously from the fiber-coating to the coating-air interface, as indicated by the increasing slope of the curve. Obviously, some of the starch migrated with the water toward the air interface of the coating upon drying and was deposited at or near the surface when the water vehicle passed into the vapor phase. The extrapolation of the curve to zero clay again shows that the fraction of total starch which penetrated the raw stock beyond the point of the clay was very small.

The starch-clay curve was graphically differentiated and the percentage of starch on the weight of the clay was plotted against the corresponding percentage of coating by weight (Fig. 9). The starch distribution curve shows that the ratio of starch to clay increases from approximately 0.15 to 0.37 between the fiber and air interface. The horizontal dotted line represents the percentage of starch in the original coating color. In general, the distribution curve is very similar to those found for the coatings on glass.

Several empirical experiments carried out with coating colors tinted with the acid dye, Crocein scarlet N Extra, are of interest in connection with the migration

of the aqueous phase upon drying. The acid dye was not appreciably adsorbed by the clay and could migrate with the free water of the color. Drawdowns of the tinted color were made on the raw stock with a Bird bar and the wet coatings were dried in various ways. Upon comparing the depth of color of the coatings visually, it was found that the coating dried with a hot air blast possessed the deepest color, whereas the coating dried at room temperature was the lightest in color. The oven-dried coatings were only slightly deeper in color than those dried at room temperature. These experiments gave a visual indication of the fact that, under certain conditions of drying, the dye concentration at the surface of the coating was increased as a result of part of the aqueous phase of the coating migrating to the surface prior to evaporation.

DISCUSSION

First, the redistribution of the adhesive vehicle between the coating and the raw stock will be discussed in a manner similar to a brief description given by Lyons (*9*), without regard to evaporation at the air interface. Essentially, the concept is analogous to the formation of a filter cake during the filtration of a coating color. At the point of application, the solid phase is presumably uniformly distributed throughout the color and the composition of the coating is homogeneous. As it wets the raw stock, the coating may migrate as a whole for a minute distance into the gross pore structure through the action of capillary forces. At the same time, the filtering out of the dispersed particles by the pores at or near the surface of the sheet begins, because the dispersed particles are either larger than the pores or are held in the pores as a result of adsorption or electrokinetic phenomena. The adhesive vehicle may continue to penetrate the raw stock, but the resistance to flow will increase because of a greater filled length of the capillaries and the decrease in the effective cross section of the surface pores caused by the accumulation of originally dispersed particles near the surface of the paper. Because of this vehicle redistribution, a minute layer or filter cake of dispersed particles is formed at or near the fiber interface. Superimposed upon this layer of high solids content, there remain strata of color whose composition varies gradually from that near the fiber interface to that of the original color near the air interface.

Penetration of the fluid phase into the raw stock may continue as long as the capillary forces in the paper are greater than the resistance to flow of the fluid phase. As penetration continues, the layer of high solids content near the fiber interface will increase in thickness, whereas the layers above will remain unchanged. Because of the pressure gradient through these deposited solids resulting from the movement of liquid, the pore volume decreases from the air to the fiber interface. When the point is reached where dispersed particles of the coating can no longer move closer together, the capillary forces in the raw stock will compete with those existing between the deposited particles of the coating. If the capillary forces in the paper are greater than those in the coating, air menisci may actually be drawn into the top of the coating. However, in view of the fact that, in general, the coating remains glossy for a considerable length of time after its application to the raw stock, it is doubtful whether air menisci are drawn into the coating.

The present concepts of the nature of dusting, picking, or flaking, and ink receptivity consider them to be related primarily to the adhesive vehicle redistribution rate of the coating color and the receptivity of the raw stock. They are based largely on rules-of-thumb obtained by experience and numerous empirical experiments which were of a qualitative nature and constituted somewhat of an indirect approach to the problem. These concepts must remain in the realm of speculation until quantitative analytical methods are developed for determining the distribution of adhesive in the coated paper and the manner in which the distribution is affected by the properties of the pigment, adhesive, and raw stock, as well as the variables in the coating operation.

The results of the present investigation suggest several concepts concerning the possible mechanisms of adhesive redistribution in the coating operation. These concepts are tentative in nature because they are formulated from experimental data that are limited and not complete. The concepts are based on laboratory coatings whose weights, methods of application, and methods of drying were considerably different from those of a commercial coating operation.

The results of the investigation suggest that the adhesive in a coating may be redistributed as a result of the penetration of the fluid phase of the color into the raw stock and/or the migration of the adhesive with the water of the coating upon drying. The redistribution of the adhesive through penetration was eliminated by application of coatings on plate glass. The results showed that the adhesive migrated upon drying and that the migration was dependent upon the weight of the coating and the method of drying. The experimental data gave a distribution curve similar to the schematic sketch in Fig. 10 for the starch content at various points within the coating.

The horizontal dotted line in Fig. 10 represents the starch content in a coating which has a uniform distribution. The solid curve illustrates that starch migrated with the water toward the air interface and that the starch content in the dried coating increased continuously from the glass to the air interface. Since the area under the distribution curves represents the total starch, this area must remain constant and equal to the area under the horizontal dotted line. Therefore, area A must be equal to area B.

The determination of the starch distribution throughout the coated paper is extremely difficult, not only because of the thinness of the coating but also because of the surface contour of the raw stock. Because the paper surface may be considered as a series of hills and valleys, points within a given plane of the coating parallel to the surface of the paper are not necessarily equally distant from the fiber interface. The techniques used in the present work for investigating the adhesive distribution in coated paper appear to be satisfactory for strata of the coating near the air interface but are of questionable value in determining the distribution of adhesive near the coating-fiber interface. In spite of this fact, it is of interest to analyze the available data and to speculate on the possible distributions of the adhesive in the region of the fiber-coating interface.

The experimental results from coatings on paper indicate that the starch and water did not penetrate the raw stock in the same proportions as represented in the original color, but the water penetrated to a much larger proportion. Some of the starch may have been prevented from migrating with the water into the raw stock because of poor dispersion and/or adsorption or electrokinetic phenomena. In general, 3 to 4% of the total starch was lost from the wet coating removed from the raw stock by scraping. This value represents the average loss of starch from the scraped coating and the actual loss from the layer adjacent to the paper may be larger. The distribution of starch in air-dried coatings on paper, as determined by the erasing technique, was found to be essentially uniform. Since these results are questionable near the fiber interface, it seems probable that the 3 to 4% starch loss likely occurred in this region.

This concept may be clarified by reference to the schematic drawing in Fig. 11 for the starch content at various points within the coated paper. The horizontal dotted curve represents an idealized case for a coating of uniform starch content and no penetraton of the raw stock. The solid curve indicates a nearly uniform distribution of starch in the top portion of the coating with the starch lost from the bottom strata of the coating having passed into the top layer of the raw stock.

This distribution of starch in the air-dried coated paper seems reasonable in view of the experimental data and the previous discussion of the mechanism of penetration of the fluid phase of the coating into the raw stock. However, this concept is not in agreement with the speculations of Rowland (*1*) on the effect of the hydrous nature of clay on penetration and its relation to dusting and picking problems in the coating process. Likewise, the distribution is at variance with the concept of Singleterry (*2*) on coating pick which implies that a deficiency of adhesive may exist in the coating a micron or so from the fiber interface.

On the other hand, it is possible that the 3 to 4% of the total starch lost from the wet coating which was removed by scraping might not actually penetrate the raw stock to any great extent but was largely retained in the portion of the coating remaining near the fiber interface. Because of the surface contour of the paper, approximately 1.5 pounds of coating per ream (25 × 40—500) remained with the paper after scraping. This fraction of the coating might have been enriched in starch from strata of the coating slightly more removed from the interface.

This concept may be clarified by reference to the schematic diagram presented in Fig. 12 for the starch content at various points within the coated paper.

The distribution of starch in the coated paper as pictured in Fig. 12 might be possible for several reasons. First, the distribution of starch in filter cakes which were formed from coating colors without filtering dry suggest a distribution similar to that shown. Second, the results on the penetration of a starch solution into the raw stock suggest that a considerable portion of the starch cannot penetrate the paper and in a coating color the proportion is probably larger because the dispersed clay particles would tend to reduce the effective cross section of the pores. Finally, the penetration of the dispersed starch into the raw stock appeared to be very slight as determined by sectioning the paper by stripping off successive layers with Scotch tape from the uncoated side and staining with iodine.

The distribution of starch in the coated paper would tend to support Singleterry's (*2*) microscopic observations of the bonding zone in coated paper. The lower adhesive content in the coating a short distance from the fiber interface would explain the cause of the weakness at the zone of failure which does not occur at the fiber interface but a short distance away in the coating.

In addition to the possibilities already pointed out, one more possible distribution warrants discussion. In the previous cases, the distribution of starch in the top portion of the coating was found to be quite uniform. However, upon drying the coating with a hot air blast from the coating side, a definite migration of the adhesive toward the top surface occurred. The resulting distribution curve was similar to those found for coatings on glass but the distribution of starch near the fiber interface is in question. This concept may be clarified by reference to the schematic diagram in Fig. 13.

The distribution curve in Fig. 13 illustrates a high starch content at the air interface of the coating. The starch content decreases upon approaching the fiber interface, but the actual distribution in this region is not definitely established. The outstanding consequence of this distribution is that a migration of adhesive to the surface of the coating upon drying might produce a significant change in the ink receptivity of the coated paper. Also, any migration of adhesive upon drying might be expected to be either toward the air and/or fiber interface. This would result in a zone of lower adhesive content within the coating which is in support of Singleterry's (*2*) concept of bonding.

The foregoing analysis is based on laboratory coatings of relatively heavy weights. However, it is believed that the observed trends are of significance in commercial operations.

CONCLUSIONS

The following conclusions are based on the study of laboratory coatings which has been presented in this paper.

1. Several techniques have been developed for studying the redistribution of the adhesive vehicle between the wet coating and the raw stock, as well as the final distribution of starch in the dried coatings.

2. The initial rate of penetration of the adhesive vehicle into the raw stock was large and decreased rapidly with time. In general, after a 2-minute contact between the wet coating and the raw stock, there was little change in the composition of the coating because of penetration.

3. The penetration of the adhesive vehicle into the raw stock decreased, in general, with increasing adhesive content of the coating color.

4. Water and starch did not penetrate the raw stock in the same proportions as represented in the original color. Approximately 3 to 4% of the total starch and 20 to 30% of the total water of the coating were lost by penetration into the raw stock.

5. The ratio of starch to clay in wet filter cakes formed from typical coating colors was found to pass through a minimum near the center of the cake and a maximum at or near the bottom of the cake.

6. A pronounced redistribution of the starch oc-

curred in the filter cakes upon oven-drying. The ratio of starch to clay at or near the top and the bottom of the cake increased, whereas the ratio in the center of the cake decreased.

7. The ratio of starch to clay in coatings on glass plates was found to increase continuously from the glass to the air interface. The nonuniform distribution of the starch in the coatings was due to a migration of the adhesive with the water toward the air interface upon drying.

8. The ratio of starch to clay in coatings on paper which were air dried at room temperature was found to be surprisingly uniform throughout. However, the ratio of starch to clay in coatings on paper which were dried with a hot air blast from the coating side was found to increase continuously from the fiber to the air interface.

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Photographic Standards for Dirt Control

WILLIAM F. CYRUS

The methods currently available for determining the customer acceptability of paper with regard to dirt involve the time-consuming evaluation of each dirt speck. The method described in this paper involves a single comparison of the entire pulp or paper sample with a series of graduated dirt standards. These standards are photographs of simulated dirt sheets which range from dirt-free to very dirty. Although this method requires but a few seconds, laboratory tests and mill scale use have demonstrated its reliability in evaluating dirt in a manner similar to the way it is judged by a customer.

Dirt in paper has long been a problem of paper mills, and with current high production demands for high quality paper, freedom from dirt has become doubly important. The methods generally used to determine the amount of dirt in pulp and paper vary from mill to mill, and in general, leave much to be desired.

Some of the methods used are: the Clark, the Graff, the method of Simonds, Billington, and Baird, the Weyerhaeuser procedure, and many others modified from these for routine mill control. A brief description of these methods should serve to point out the differences between them, and some of the shortcomings of each (*1*).

The Clark method has been accepted as the tentative TAPPI standard for both pulp and paper (*2*). It is one of the few methods which uses a dry sheet and reflected light, and determines the "equivalent black area" of dirt spots. The "equivalent black area" of a dirt spot is defined as the area of a black spot on a white background which would make the same visual impression as does the dirt spot itself on the background on which it is imbedded. Although the estimation of the "equivalent black area" causes some human error, the major objection to this method is that it is so time consuming for routine mill control.

Most of the other methods, mentioned above, count total dirt specks, regardless of their size or color. These counts are made on wet sheets with transmitted light. The dirt is reported as total dirt specks per unit weight of pulp or paper, except in the method of Simmonds, Billington, and Baird where the dirt specks are grouped according to diameter in addition to the total number of specks. Although these methods all use transmitted light, the type and intensity of light vary. This variation has been shown to affect dirt counts of this type (*1*). As in the TAPPI method, one of the major objections to these methods is that for routine mill control, they require too much time.

From the standpoint of customer acceptability, it will probably be agreed that the amount of dirt in paper is relatively unimportant in itself, but that the effect of the amount of dirt, which is whether the paper looks dirty or not, is important. Dirt count methods which just count the total number of dirt specks without considering the size and color of the specks, nor the color of the background do not tell us whether the paper actually looks dirty or not.

The TAPPI method considers this as their definition of dirt will explain (*2*). TAPPI says, "Dirt in pulp is defined as any foreign matter which is imbedded in a sheet, which has a marked contrasting color to the rest of the sheet when viewed by reflected light and which has an 'equivalent black area' of 0.08 mm.^{2} (for paper 0.04 mm.^{2}) or more. As mentioned earlier, the 'equivalent black area' of a dirt spot is defined as the area of a black spot on a white background which would make the same visual impression as does the dirt spot itself on the background in which it is imbedded."

It is the term "visual impression" which holds the key to the effectiveness of the TAPPI method with regard to whether or not the paper looks dirty. In this method the "visual impression" of each dirt spot must be considered. This involves considerable human judgment for each single spot, and there may be over a hundred spots to estimate for each final value.

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In order to reduce the time required and the human error involved in making estimates of the effect of each single dirt spot upon the appearance of a sample, a method was devised which requires but a single estimate of the effect of all the dirt spots upon the sample as a whole. By this method, therefore, the size, color, and number of dirt specks, and the color of the background are automatically considered.

The "dirt standards method," as it shall be referred to consists of comparing the sample in question with a set of graduated dirt standards. The dirt standards are numbered according to how dirty they look, and in operation, the number of the dirt standard which most nearly gives the same visual impression of dirt as the sample is recorded as the "Dirt Number." The comparison is made rapidly, for prolonged study merely serves to confuse the observer.

In making the dirt standards, different methods were tried and discarded until satisfactory standards were obtained. At first, four sets of standards were made—one set each for book groundwood, news groundwood, bleached and unbleached sulphite. The sheets were made from the pulp in question, and dirt was added to make up each series. There were five standards of different dirt content for each of the pulps. The standards could not be used very long before they acquired too much surface dirt, and since making them up in this manner was such a painstaking process, a more expedient procedure was sought.

Photostats were made of these dirt sheets, and also of simulated, pen and pencil dirt sheets, but neither of these two methods proved successful.

The final approach was to photograph simulated dirt sheets prepared by using pen and pencil marks of suitable character on a white background. Prints made from these negatives were enlarged back to $4^1/_2$ by $4^1/_2$ inches, the size of the original dirt sheets. The standards made in this manner were clear and the formation of the printing paper did not cause any trouble.

Originally, a set of five standards for each of the four pulps mentioned was made, but the number of separate standards required at each testing station was so great, and the range of each set so small that a single set of standards for all pulps was made. The final series of standards was numbered from one to nine, number one being free from dirt, and number nine being what would ordinarily be judged as very dirty.

PROCEDURE

The procedure for paper differs from that for pulp. Only the surface dirt contributes to the appearance of paper, so in making a dirt evaluation of paper a dry sheet and reflected light are used. A $4^1/_2$-inch square is marked off on the dry sample, and compared with the standard using only reflected light.

With pulp, all dirt contained in the sheet may contribute to the surface dirt of the finished paper, and by using a wet sheet and transmitted light, even imbedded dirt may be seen. The comparison can be made on pulp handsheets. A $4^1/_2$ by $4^1/_2$-inch template is painted on the frosted glass of a light box, and the wet handsheet is placed over this for the determination. The standards are placed next to the handsheet, and both are viewed with transmitted light.

VARIABLES

The variables affecting dirt counts which were mentioned previously have little or no effect on this method. Since both the sample and the standards are viewed at the same time and under the same identical conditions, factors such as intensity and kind of light will have minor effect, and the distance of the observer's eyes from the sample is unimportant.

The two variables remaining are basis weight and the human element. The basis weight is important only with pulp since all imbedded dirt is counted. With too light a sheet, the sample is not representative, but as the basis weight increases, the dirt becomes obscured because insufficient light is transmitted, The optimum basis weight has been found by observation to be about 37 pounds which value has also been used by other investigators (*1*).

The human element should have less effect upon the results of the dirt standards method than upon most other methods since the dirt sheet as a whole is compared with a limited number of standards, instead of considering each speck singly.

RELIABILITY

Although these dirt standards are not of actual pulps, the results are reproducible, and what may be equally important, the fact that the standards can be made from the negatives so easily should enable several mills to use the same standards and get comparable results.

In testing out this method, three observers, working independently, picked the same number dirt standard for over 360 out of 400 dirt sheets. This indicates that the reliability of the method is better than 90%. In those cases where the same standard was not picked the next standard either above or below was selected.

The dirt standards method has demonstrated its value in the mill by actual use as a routine mill control test.

SUMMARY

The differences between various dirt count methods have been briefly pointed out, and the dirt standards method has been explained. Findings with respect to variables, advantages, and reliability have been indicated.

The only two variables of significance were basis weight and the human element. The basis weight is of importance only with pulp, and can be easily controlled. The human element should have less effect on this method than on other methods in general use.

The advantages are: it is fast, and the results are reproducible. The ease with which the standards can be made should enable several mills to use the same standards and get comparable results.

The reliability has been shown to be better than 90%, and in actual routine mill use, the method has been found to be of value in quickly evaluating dirt content in the same manner that it is judged by a customer.

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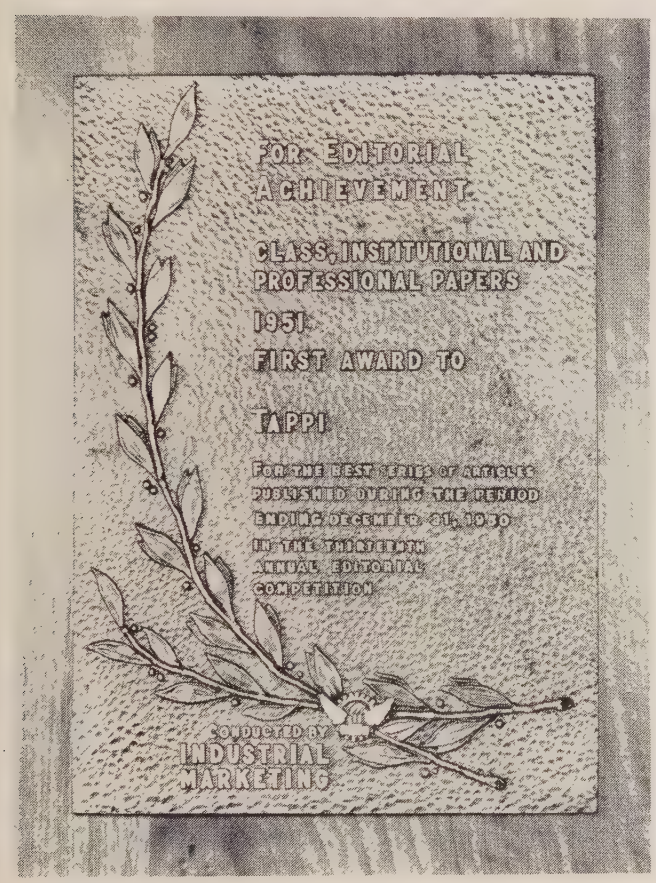
ASSOCIATION NEWS AND EVENTS

Tappi Wins Industrial Marketing Editorial Competition

On May 21 R. S. Aitchison, Editor of *Industrial Marketing* wrote to the Editor of *Tappi* as follows:

"Please accept our congratulations.

"It is a pleasure to tell you that *Tappi* is a winner in the 13th Annual Editorial Achievement Competition. Your excellent story 'Effect of Fiber Characteristics on Paper and Papermaking Properties,' won the first place plaque for the best series of articles among class, institutional and professional publications."



The plaque was presented to R. G. Macdonald, Editor of *Tappi*, at the luncheon meeting held during the annual conference of the National Industrial Advertisers Association at the Waldorf-Astoria Hotel in New York on June 27. Bernard M. Dolan, Manager of Sales, Peter A. Frasse & Co., Inc., New York, N. Y., and Past-President of the NIAA presented the plaque.

The series of articles referred to appeared in the August and September 1950 issues of *Tappi* and were the papers presented at the TAPPI-CPPA Fundamental Research Conference held at Quebec City in May, 1950, in which many from the United States, Canada, Great Britain, and Sweden participated. The conference and the papers were significant in that they represented the first concerted effort to bring together considerations relative to the fundamentals concerning the nature of sheet formation in the manufacture of paper.

The runner-up in the competition was the *Military Engineer*. Several hundred publications were entered in the competition. Since the competition has been going on for 13 years, *Tappi* is gratified in attaining this high standing among professional magazines in its second year of existence. The judges were highly qualified individuals representing nationally known industrial advertisers and advertising agencies.

Alkaline Pulping Conference

The Alkaline Pulping Conference of the Technical Association of the Pulp and Paper Industry will be held at the John Marshall Hotel, Richmond, Va., on September 26–28, 1951. Henry Vranian of the Chesapeake Corp., West Point, Va., is General Chairman of the Conference and R. R. Fuller of the Gulf States Paper Co., Tuscaloosa, Ala., is Program Chairman.

A feature of the meeting will be the visit to Chesapeake Corp. and Historical Williamsburg, Va., on September 28.

The tentative technical program follows:

September 26, 1951

9:00 a.m. General Session
Henry Vranian.
1. Available Woody Raw Materials.
2. Wood Harvesting Wastes Available.
3. Wood Loss in Handling Systems.
4. Conveying Systems.
5. Checking Wood Quality.
6. Effect of Knives on Chip Quality.

12–2:00 p.m. Lunch

2:00 p.m.
1. Wood Losses in Chipper Operation.
2. Barking, Chipping Hardwood.
3. Possibilities in Forest Management.

Discussion Panel: Wood Utilization and Wood Room

3:30 p.m. Cooking Processes
1. Coating Ingredients from Tall Oil.
2. Effect of Bark in Sulphate Pulping of Slash Pine.
3. Continuous Cooking.

September 27, 1951

9:00 a.m. Cooking Processes
1. Cooking of Knots and Rejects.
2. Odor Problems in Sulphate Pulping.
3. Hard Cooking of Northern Wood.
4. Discussion of Controls, Circulation and Indirect Heaters.
5. Semichemical Pulping and Wood Species.
6. Scandinavian Pulping Practice.

12–2:00 p.m. Lunch

2:00 p.m. Cooking Processes
1. Cooking Hardwoods by the Sulphate Process.
2. Neutral Sulphite Semichemical.

Discussion Panel

Container Testing Committee

Charles Krebs of the Atlas Boxmakers, Inc., Chicago, Ill., Chairman of the Container Testing Committee, has called a meeting of the Advisory Group of this committee to be held at the Statler Hotel, Cleveland, Ohio, on Oct. 3, 1951, at the time of the meeting of the Industrial Packaging Engineers Association.

Sixth Engineering Conference

The Sixth Engineering Conference of the Pulp and Paper Industry will be held at the General Oglethorpe Hotel, Wilmington Island, Savannah, Ga., on Oct. 15–18, 1951.

Following is the program:

Sunday, October 14

6:30–9:00 p.m. Registration (Sunrise Lounge)

Monday, October 15

8:30–9:30 a.m. Registration (Sunrise Lounge)

9:30 a.m. General Session (Crystal Ballroom)
G. H. Pringle, Mead Corp., Chillicothe, Ohio, *Chairman*

Addresses of Welcome by G. W. E. Nicholson, Union Bag & Paper Corp., Savannah, Ga., and J. E. A. Warner, for Southern Paperboard Corp., Port Wentworth, Ga.

10:00 a.m. Engineering Research and Machine Design Session (Crystal Ballroom)
John D. Lyall, Armstrong Cork Co., Lancaster, Pa., *Chairman*

"A Study of the Calender," by Eli Cowan, Consulting Engineer, Montreal, P. Q.

"Capacity of Thickeners," by Robert A. Nivison, Improved Paper Machinery Co., Nashua, N. H.

11:30 a.m. Data Sheets Session (Crystal Ballroom)
Henry J. Perry, *Paper Trade Journal*, New York, N. Y., *Chairman*

"A System of Gathering Data Sheets," by Henry J. Perry, *Paper Trade Journal*, and R. T. Bingham, Technical Association of the Pulp and Paper Industry, New York, N. Y.

12:00 Luncheon

Engineering Division Committee Luncheons:

Engineering Division and Machine Design Committee (Wilmington Room).

Mill Maintenance and Materials Committee (Tower Room).

Hydraulics Committee (Whitemarsh Room).

Chemical Engineering Committee (Yacht Room).

2:00 p.m. Mill Design and Economic Aspects Session (Crystal Ballroom)
Roland A. Packard, Consulting Engineer, South Hadley Falls, Mass., *Chairman*

"Pump Difficulties in Pulp and Paper Mills," by Parkman A. Collins and J. G. Rearick, Warren Steam Pump Co., Warren, Mass.

Panel discussion of the "drop-leg problem" as applied to flat boxes under paper machine wires led by C. L. Clark, Clark & Vicaro, Bronxville, N. Y.

"Mill Engineers Selection of the Paper Machine Drive, Part II," by Roland A. Packard, South Hadley Falls, Mass., and Alfred N. Ball, E. B. Eddy Co., Ltd., Hull, Que.

3:30 p.m. Discussion Sessions

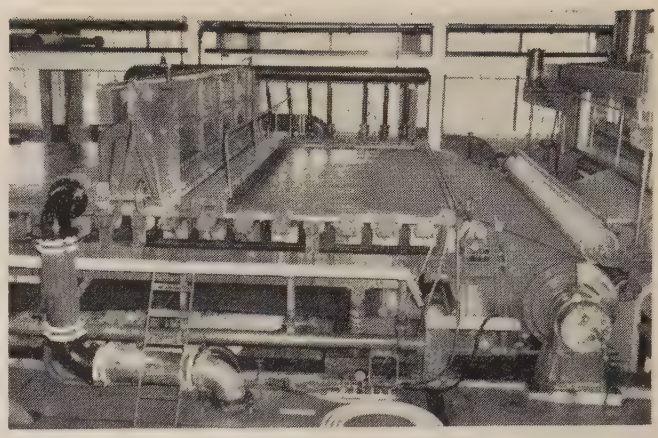
A. Engineering Research and Machine Design (Crystal Ballroom)
John D. Lyall, *Chairman*

"Subcommittee Report on Centralized Control of Stock Systems" by L. A. Moore, American Coating Mills, Elkhart, Ind.

"Subcommittee Report on Study of Hardness of Rubber-Covered Rolls and the Effect on Water Removal," by K. W. Brenner, Eastman Kodak Co., Rochester, N. Y. (There will be a presentation on the use of the Pusey & Jones Plastometer and a discussion of various ways of measuring nip areas so that standards can be established.)

"Subcommittee Report on Methods of Estimating Costs of Engineering Projects and Consideration of Indices that May Be Used," by H. G. Ingraham, Chas. T. Main, Inc., Boston, Mass.

"Subcommittee Report on Felt Tension in the Press and Methods of Its Measurement," by G. E. Clink, Sandy Hill Iron & Brass Works, Hudson Falls, N. Y.



High speed kraft fourdrinier with secondary headbox

B. Chemical Engineering (Tower Room)
J. R. Lientz, Union Bag & Paper Corp., Savannah, Ga., *Chairman*

Progress Report on Digester Corrosion.

C. Mill Design and Economic Aspects (Yacht Room)
Roland A. Packard, *Chairman*

Discussion of the "Vacuum Drop Leg Problem"

7:00 p.m. Southern Barbecue (General Oglethorpe Hotel Grounds)

Tuesday, October 16

8:00 a.m. Data Sheets Committee Breakfast (Wilmington Room)
Henry J. Perry, *Chairman*

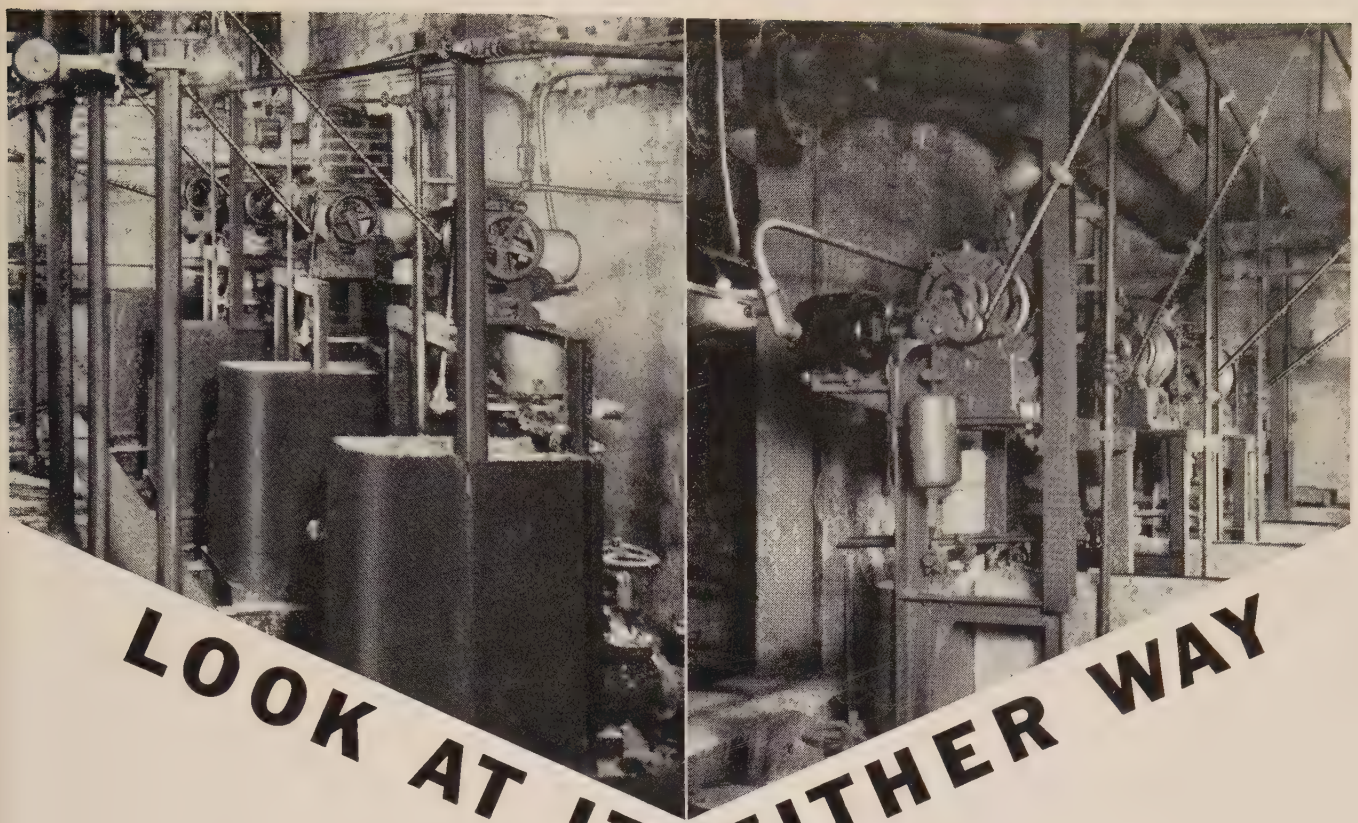
(All Chairmen and Secretaries of Committees are invited to attend this breakfast to discuss ways and means of obtaining more data sheets.)

9:00 a.m. Hydraulics Session (Crystal Ballroom)
K. J. Mackenzie, Eastman Kodak Co., Rochester, N. Y., *Chairman*

"A Shear Criterion for the Correlation of Hydraulic Behavior of Paper Stock in Pumps, Pipes, Valves, and Flow Meters," by Victor P. Head, Director of Hydraulics Research, Fischer & Porter Co., Hatboro, Pa.

"Interim Report on Pipe Friction Studies at the University of Maine," by Lyle C. Jenness, Head, Department of Chemical Engineering, University of Maine, Orono, Me.

"The Distribution of Velocity Gradients of Paper Stock in Pipes," by E. Hobbs and Geoffrey Broughton, Lowell Textile Institute, Lowell, Mass.



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10:30 a.m. Steam and Power Session (Crystal Ballroom)
C. J. Sibler, West Virginia Pulp & Paper Co., New York, N. Y., *Chairman*

"Materials and Design of Piping Systems for High-Pressure and High-Temperature Service," by Eric A. Kerbey, Midwest Piping & Supply Co., St. Louis, Mo.
"Gas Turbine Applications in the Paper Mill," by W. C. Bloomquist, General Electric Co., Schenectady, N. Y.

12:00 Luncheon

Engineering Division Committee Luncheons:
Steam and Power Committee (Whitemarsh Room).
Electrical Engineering Committee (Tower Room).
Drying & Ventilating Committee (Yacht Room).
Materials Handling Committee (Wilmington Room).

2:00 p.m. Electrical Engineering Session (Crystal Ballroom)
Ray Foster, Champion Paper & Fibre Co., Canton, N. C., *Chairman*

"The Power Requirements of Fourdrinier Sections," by W. Mikelson, General Electric Co., Schenectady, N. Y.
"The Application of Cables in Pulp and Paper Mills," by A. O. Mortenson, St. Regis Paper Co., Pensacola, Fla.

3:30 p.m. Discussion Sessions

A. Electrical Engineering (Tower Room)
Ray Foster, *Chairman*

"Preliminary Report on Power Requirements for Press Sections of Paper Machines," by R. R. Baker, Westinghouse Electric Corp., East Pittsburgh, Pa.
Discussion of Papers presented at the Electrical Engineering Session.

B. Steam and Power (Crystal Ballroom)
C. J. Sibler, *Chairman*

"Cinder Collection," by G. W. Bollinger, West Virginia Pulp & Paper Co., Charleston, S. C.
"Education of Power Plant Engineers," by M. F. Schnaufer, Detroit Sulphite Pulp & Paper Co., Detroit, Mich.

C. Hydraulics (Yacht Room)
K. J. Mackenzie, *Chairman*

Discussion of Papers presented at the Hydraulic Sessions.

7:00 p.m. Get-together Party and Dinner (General Oglethorpe Grounds) (Sponsored by Allied Industries)

Wednesday, October 17

9:00 a.m. Drying and Ventilating Session (Crystal Ballroom)
Marshall L. Barker, Beckett Paper Co., Hamilton, Ohio, *Chairman*

"High-Pressure Driers," by Charles P. Spalding, Beloit Iron Works, Beloit, Wis.
"Ventilation for Comfort of Personnel," by L. G. Janett, J. O. Ross Engineering Co., New York, N. Y.

10:30 a.m. Materials Handling Session (Crystal Ballroom)
A. P. Schnyder, Ebasco Services, New York, N. Y., *Chairman*

"Woodmill Log Handling in the Pulp and Paper Industry on the West Coast," by W. H. Rambo and H. A. DeRice, Industrial Plant Engineers, Portland, Ore.
"Wood Handling Methods in Pulp Mills of Eastern North Carolina and Virginia," by C. L. Wills and C. L. Hildebrand, Halifax Paper Co., Roanoke Rapids, N. C.
"Pneumatic Conveyors," by H. A. Stoess, The Fuller Co., New York, N. Y.

12:15 p.m. Engineering Division Luncheon (Main Dining Room)
Guest speaker to be announced.

2:15 p.m. Mill Maintenance and Materials Session (Crystal Ballroom)
H. F. Parker, New York & Pennsylvania Co., Lock Haven, Pa., *Chairman*

"Use and Maintenance of Steel Sash in Pulp and Paper Mills," by K. S. Frazier, Detroit Steel Products Co., Detroit, Mich.
"Electrical Maintenance, Including Electronic Equipment," by H. R. Meyer, Westinghouse Electric Corp., E. Pittsburgh, Pa.

3:45 p.m. Discussion Sessions

A. Mill Maintenance and Materials (Crystal Ballroom)
H. F. Parker, *Chairman*

"Maintenance of Insulation in Pulp and Paper Mills," by Paul Corning, Rayonier Inc., Fernandina, Fla.

B. Materials Handling (Tower Room)
A. P. Schnyder, *Chairman*

"Methods and Means of Delivering Pulpwood to the Mill Yard"

C. Drying and Ventilating (Yacht Room)
Marshall L. Barker, *Chairman*

"Translation from German of Application of the Laws of Drying and Ventilating to the Design and Operation of Pulp and Paper Machine Driers," by Karl Schmitt.

7:00 p.m. Dinner (Where you Will)
Dinner of Chairmen and Secretaries of Engineering Division Committees (Yacht Room).

Thursday, October 18

9:00 a.m. Visit to Mill of the Union Bag & Paper Corp., Savannah, Ga.

(Buses will leave Hotel at 9:00 a.m.)

12:30 p.m. Barbecue Luncheon at Mary Calder Golf Course (Guests of Union Bag & Paper Corp.)

2:00 p.m. Visit to Mill of the Southern Paperboard Corp., Port Wentwoth, Ga.

(Individuals who wish to return to the Union Bag & Paper Corp. mill for special department visits may do so.)

Other plants that will be open to visitors will be the Herty Foundation Laboratory, Savannah, Ga.; Brunswick Pulp and Paper Co., Brunswick, Ga.; West Virginia Pulp & Paper Co., Charleston, S. C.; and the Macon Kraft Co., Macon, Ga. Individuals wishing to visit these plants should make advance arrangements with the management of these companies.

Note: There is a swimming pool located on the grounds of the General Oglethorpe Hotel and the De Soto Hotel. Excellent golf facilities are also available.

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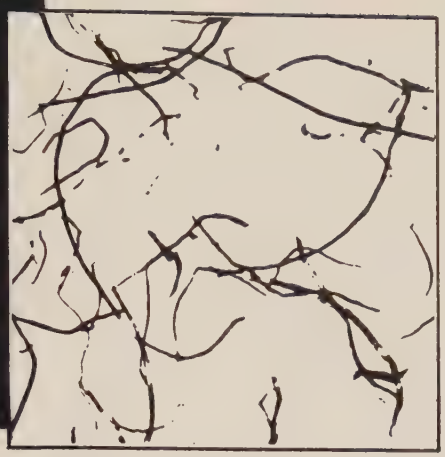
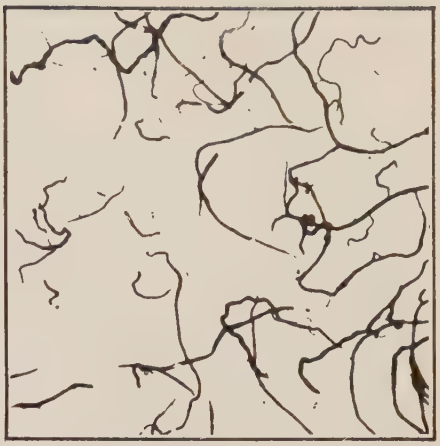


Uncurlated Bleached Southern Kraft



Curlated Bleached Southern Kraft

Photomicrographs of curlated and uncurlated pulp, showing how much curlation bends and twists fibers . . . changes fiber shape and diameter . . . yet, does not affect freeness. Any fiber bundles and dirt with the fibers are reduced by Curlator's patented rubbing and rolling process. *Note* in uncurlated photomicrographs how straight and coarse the fibers are . . . then see how curlation curls and thins fibers. That's why curlation makes a softer, more flexible, springier, smoother sheet.

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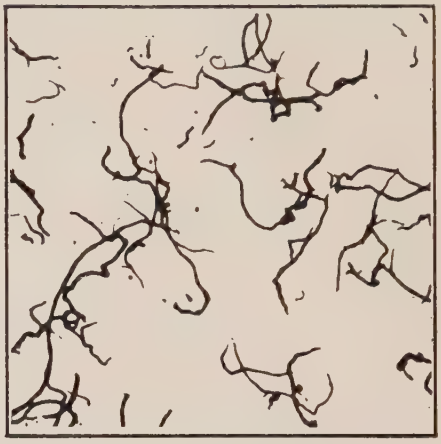

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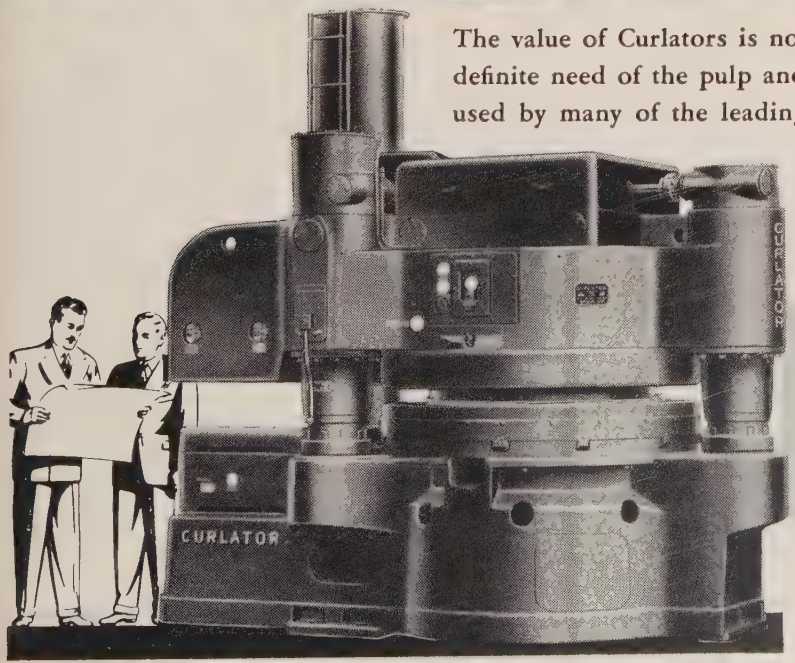

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PERSONAL MENTION

Items About New and Old Tappimen

New TAPPI Members

Lucien F. Barriere, Chief of Laboratory, North African Cellulose Co. "Cellunaf," Algerie, S. A., a graduate of the University of Bordeaux.

Caleb Binns, Research Manager, Robert Fletcher & Son Ltd., Greenfield, nr. Oldham, England, a graduate of the University of London with a Ph.D. degree.

Myron W. Block, Quality Control Supervisor, Stone Container Corp., Chicago, Ill., a 1935 graduate of the University of Arkansas.

John Bonnett, Chemical Salesman, Monsanto (Canada) Ltd., Montreal, P. Q., Canada, a 1949 graduate of McGill University.

Robert E. Bringman, Chief Chemist, St. Joe Paper Co., Port St. Joe, Fla., a 1948 graduate of the University of Wisconsin.

Elmer R. Burling, Vice-President, Improved Paper Machinery Corp., Nashua, N. H., a 1930 graduate of Massachusetts Institute of Technology.

Robert M. Carr, Assistant Engineer, Armstrong Cork Co., Arrowhood Plant, Fulton, N. Y. Attended Syracuse University.

Carl P. Caspari, Examiner, The Norwegian Patent Office, Oslo, Norway, a 1920 graduate of the Norwegian Technical University.

Victor E. Casper, Maintenance Superintendent, Moraine Paper Co., W. Carrollton, Ohio.

Joseph D. Chadderdon, Chemist, Kalamazoo Vegetable Parchment Co., Parchment, Mich., a 1943 graduate of Western Michigan College.

John C. Clapper, Research Assistant, Hollingsworth & Vose Co., E. Walpole, Mass., a 1943 graduate of Michigan State College.

Daniel L. Cleary, Assistant Paper Chemist, Moraine Paper Co., W. Carrollton, Ohio. Attended Ohio State University and University of Cincinnati.

Burton K. Clifford, Special Research Sales Engineer, Union Bag & Paper Corp., New York, N. Y., a 1923 graduate of Bates College.

Louis A. Dahlem, Engineer, Syndicat des Fabricants de Pates et Papiers de Pin Maritime Francais, Bordeaux, France.

George F. DeLong, Chief Chemist, Hinde & Dauch Paper Co. of Canada Ltd., Toronto, Ont., Canada, a 1933 graduate of the University of New Brunswick.

John A. Donahue, Technical Service Engineer, Hercules Powder Co., Kalamazoo, Mich., a 1948 graduate of Massachusetts Institute of Technology.

Aarno J. Esila, Superintendent of Sulphate Pulp Mill, Ab Kemi Oy, Karihaara, Finland, a 1947 graduate of The Technical University, Helsinki.

Joseph J. Fiori, General Manager of Mill Operations, Stone Container Corp., Franklin, Ohio.

Eugene M. Flint, President, Vapo Systems Co., Maywood, Ill.

Gilbert Franck, Chemical Engineer, Cartonneries de la Rochette, Paris, France, a 1950 graduate of College of Physics and Chemistry.

Benjamin Grodman, Director, Central Testing Laboratory, Dept. of Purchase, City of New York, New York, N. Y., a 1911 graduate of the College of the City of New York.

Donald D. Hall, Manager of Materials Handling, The E. B. Eddy Co., Hull, P. Q., Canada, a 1930 graduate of Queens University.

Jesse M. Holderby, Manager, By-Products Div., Rhinelander Paper Co., Rhinelander, Wis., a 1924 graduate of State University of Iowa with an M.S. degree.

George F. Huber, Research Assistant, Keyes Fibre Co., Waterville, Me., a 1943 graduate of South Dakota State College.

Marsden C. Hutchins, Research Chemist, American Cyanamid Co., Calco Chemical Div., Bound Brook, N. J., a 1949 graduate of the University of Maine with an M.S. degree.

Voitto W. Jarvi, Coating Superintendent, Falulah Paper Co., Fitchburg, Mass.

Heinrich C. Jessen, Project Manager, Johns Manville Corp., New York, N. Y., a graduate of Technical University, Trondheim, Norway.

Wesley O. Johnson, Maintenance Engineer, Marathon Corp., Menominee, Mich., a 1942 graduate of the University of Wisconsin.

Johannes Jung, Engineer-Manager, Biffar & Jung, Miltenberg/Maine, Germany, U. S. Zone, a 1921 graduate of Polytechnic College, Ilmenau.

Alexander S. Kasser, Manager, Pulp Development Dept., Parsons & Whittemore, Inc., New York, N. Y., a 1928 graduate of University of Sorbonne, Paris, and a 1932 graduate of University of Grenoble, France.

Leo O. Lake, Chemist, Kalamazoo Vegetable Parchment Co., Parchment, Mich., a 1942 graduate of Western Michigan College.

Ralph M. Leighton, Chief Chemist, Stowe-Woodward, Inc., Newton Upper Falls, Mass., a 1918 graduate of the University of Maine.

Edwin F. Libby, Plant Engineer, West Virginia Pulp & Paper Co., Charleston, S. C.

Walter J. Macey, Adhesive Chemist, St. Regis Paper Co., Oswego, N. Y.

Ugo Mancini, General Manager, "Chatillon" Societa Anonima Italiana per le Fibre Tessili Artificiali S.P.A., Milano, Italy, a graduate of the Politecnico College, Milano.

James A. McLean, Assistant Superintendent, Great Northern Paper Co., Madison, Me., a 1933 graduate of the University of Maine.

Peter J. Metz, Divisional Technical Supervisor, Western Waxed Paper Div., Crown Zellerbach Corp., San Leandro, Calif., a 1938 graduate of St. Norbert College.

Donald F. Meyer, Assistant Director of Control Laboratories, Central Paper Co., Inc., Muskegon, Mich., a 1949 graduate of the University of Michigan.

Julio Molleda, Student, New York State College of Forestry, Syracuse, N. Y., a 1946 graduate of Forestry College, Madrid, Spain.

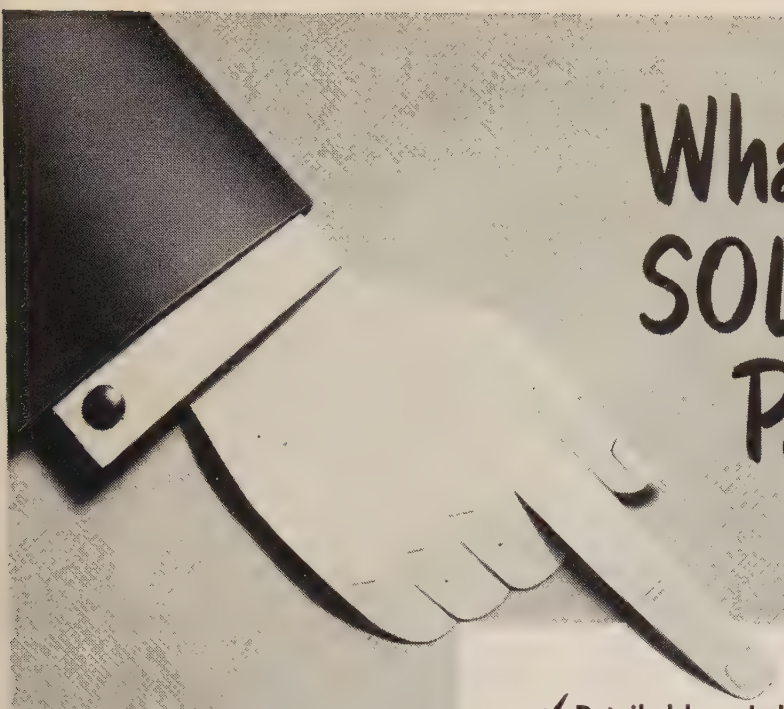
Thomas J. Muldoon, Project Leader, General Foods' Central Research Laboratories, Hoboken, N. J., a 1942 graduate of St. Peter's College.

Robert Nivison, Jr., Sales Manager, Improved Paper Machinery Corp., Nashua, N. H. Attended the University of Maine.

Waldo M. Orchard, G. D. Jenssen Co., Inc., Watertown, N. Y., a 1937 graduate of Acadia University, Wolfville, N. S., Canada.

Frank W. Partsch, Vice-President in Charge of Boston Office, J. O. Ross Engineering Corp., Boston, Mass.

Morley E. Patterson, Kraft Pulp Mill Superintendent, Pacific Mills Ltd., Ocean Falls and Vancouver, B. C., Canada.



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Ralph F. Patterson, Technical Director, Powell River Co. Ltd., Powell River, B. C., Canada, a 1942 graduate of McGill University with a Ph.D. degree.

Frederick C. Paul, Chemist, Hudson Pulp & Paper Corp., Palatka, Fla., a 1922 graduate of Massachusetts Institute of Technology.

Maurice H. Pickard, Technical Director, Pacific Coast Borax Co., Div. of Borax Consolidated Ltd., New York, N. Y., a 1923 graduate of Tufts College.

Julien O. Raick, Managing Director, Syndicat de la Cellulose Africaine, Brussels, Belgium, a graduate of Liege University, Belgium, and of Leland Stanford University, California.

Avie C. Reece, Technical Service Representative, Buckman Laboratories, Inc., Memphis, Tenn., a 1948 graduate of Mississippi State College.

William E. Roseveare, Research Associate, E. I. du Pont de Nemours & Co., Richmond, Va., a 1928 graduate of the University of California with a Ph.D. degree.

Joseph S. Scheuermann, Vice-President and Sales Manager, Converting Div., Bagley & Sewall Co., Watertown, N. Y.

Vivian M. Smith, Acquisition Div., University of Georgia Libraries, Athens, Ga.

William E. Soles, Assistant General Manager, Anglo-Canadian Pulp & Paper Mills, Ltd., Quebec, P Q., Canada, a 1935 graduate of Queens University.

Robert W. Stoertz, Control Laboratory Director, West Virginia Pulp & Paper Co., Charleston, S. C., a 1938 graduate of Pennsylvania State College.

Wolfgang von Spiegelfeld, Secretary and Export Manager, Paul F. Marxov, Inc., New York, N. Y., a 1937 graduate of the University of Vienna.

James R. Wall, Senior Research Chemist, Aluminum Co. of America, E. St. Louis, Ill., a 1926 graduate of the University of Illinois.

Eugene J. Ward, General Sales Manager, Cameron Machine Co., Brooklyn, N. Y. Attended New York University, Polytechnic Institute of Brooklyn and Hofstra College.

David F. Williams, Assistant Chief Chemist, Champion Paper & Fibre Co., Houston, Tex., a 1941 graduate of the University of Colorado.

Richard D. Zirker, District Representative, Shell Chemical Corp., Portland, Ore., a 1941 graduate of U. S. Naval Academy.

TAPPI Notes

Denton Anderson, formerly of the Snyder Chemical Co., is now Asst. Vice-President, Flax Corp., Hartford, Conn.

Sydney Annett, formerly of Monsanto (Canada) Ltd., is now in the Sales Dept., Lignosol Chemicals Ltd., Quebec, P. Q.

Clarence G. Bennett, formerly of the Paterson Pacific Parchment Co., is now Director of Product Development and Consumer Research, Pacific Coast Foil Co., Division of Jorgenson & Co., San Francisco, Calif.

Herman L. Berg, formerly of Bulkley, Dunton Pulp Co., is now Engineer for the Sveen-Pederson Sales Corp., Long Island City, N. Y.

Per Bro, formerly student at Yale University, is now Instructor in Chemical Engineering, Clarkson College of Technology, Potsdam, N. Y.

Miss Chung Ying Chu, formerly student at the University of Maine, is now in the Research Division, International Paper Co., Glens Falls, N. Y.

Cliff R. Crawford, formerly Vice-President of Shartle Bros. Machine Co., is now President of the Black-Clawson Co., Hamilton, Ohio.

Le Roy S. Diffenbach, of the Hercules Powder Co., has been transferred from Wilmington, Del., to the P.M.C. Department, Holyoke, Mass.

Paul Easton, formerly of the Bulkley, Dunton Pulp Co., is now Vice-President and Sales Manager, Sveen-Pederson Sales Corp., Long Island City, N. Y.

Miss Lois V. Hans, formerly of the St. Regis Paper Co., is now Technologist at the Philadelphia Quartermaster Depot, Philadelphia, Pa.

Fred Herbolzheimer, Jr., formerly of the Marinette Paper Co., is now Asst. Superintendent, Pulp Preparation Dept., Scott Paper Co., Chester, Pa.

Walter W. Holland, formerly of the Quebec North Shore Paper Co., is now Manager of Production, Oxford Paper Co., Rumford, Me.

K. M. Paul Hsi, formerly of the St. Regis Paper Co., is now Engineer with Roderick O'Donoghue, New York, N. Y.

Miss Gloria E. Hunter, formerly student at the College of Forestry, Syracuse University, is now with the Dixie Cup Co., Easton, Pa.

Ingmar Jaatinen, formerly of Ahlstrom O/Y is now with O/Y Toppila, Oulu, Finland.

Alfred E. Johnson, formerly of Consolidated Machine Tool Co., is now Technical Supervisor, Curlator Corp., Rochester, N. Y.

Stuart E. Kay, is now Vice-President of the International Paper Co., New York, N. Y.

Richard H. Laftman, formerly of the National Container Corp., has retired and is now living in Saltzjo-Duvnas, Sweden.

John R. Leggett, formerly of the Barrett Div., Allied Chem. & Dye Corp., is now Engineering Assistant, The Hudson Pulp & Paper Corp., Palatka, Fla.

Homer D. Martindale, formerly President of the Black-Clawson Co., Hamilton, Ohio, is now Chairman of the Board of Directors.

J. O. Mason, formerly Vice-President of the Mead Corp., Chillicothe, Ohio, is now Consultant for the Company.

James C. Morris, is now Vice-President of Production, The Ohio Boxboard Co., Rittman, Ohio.

Robert W. Pattison, formerly of Cellulose Fibres, Inc., is now President and General Manager of Cellulose Pulp Products, Inc., N. Wilbraham, Mass.

Arthur Patureau, formerly of Fischer & Porter Co., is now Staff Engineer, Valve Division, Minneapolis-Honeywell Regulator Co., Philadelphia, Pa.

Alfonso Rugerio, formerly student at the Institute of Paper Chemistry, is now Secretary of Cia Industriel Papelera Poblana S. A., Puebla, Mexico.

Gabriel T. Turula, formerly of the American Coating Mills, is now Quality Control Supervisor and Chemist, Empire Box Corp., Stroudsburg, Pa.

Curtis S. Walseth, formerly of the Union Bag & Paper Corp., is now in the Research Department, Pulp Division, Weyerhaeuser Timber Co., Longview, Wash.

* * *

John L. Larson, Vice-President, has succeeded Sydney Steel as the official representative of Fischer & Porter Co., Hatboro, Pa., in the Technical Association.

D. H. Gleaves, official corporate representative of the National Gypsum Corp. in TAPPI, has moved his office from Clarence Center, N. Y., to Box 1528, Mobile, Ala.

Industry Notes

Carl Schleicher & Schuell Co., manufacturers of analytical and filter papers, has moved from New York City to Keene, N. H. Russell J. Eddy, President, is a member of the Technical Association.

* * *

The Tremont Lumber Co. offices have moved from 307 N. Michigan Ave. to 1 N. La Salle St., Chicago 2, Ill.

VALUE in a fine product reflects the experience and skills of its makers.

VALUE in Fourdrinier wires is a matter of record... paper quality and production records in mills throughout America reflect the fact that *Appleton Wires are Good Wires!*

APPLETON WIRE WORKS, INC.
APPLETON • WISCONSIN

Arrangements have been made to manufacture a limited line of Shartle Bros. Machine Co., Middletown, Ohio, stock preparation equipment in Italy. The equipment which includes Hydrapulpers, Hydrafiners, Jordans, screens and replacement parts will be manufactured from American drawings by Fabbrica Macchin S.P.A., Naples, Italy. Milos Krofta is the Black-Clawson representative in Milan, Italy, for Austria and Italy.

C. R. Crawford, new President of Black-Clawson, has been re-elected Director of the British subsidiary, B-C International, Ltd., London, England.

* * *

Thirty members of the graduating class of the Pulp and Paper Course, New York State College of Forestry, visited the plant of the Sandy Hill Iron & Brass Works at Hudson Falls, N. Y., on May 7. The paper machine in the College of Forestry laboratory was made by Sandy Hill. Following a tour of the machine shops and other parts of the plant the students watched a demonstration of the Peppy Peeler. In the evening the students were guests of Sandy Hill at a dinner given at the Queensbury Hotel. Brief talks were given by Vance P. Edwardes, Consultant, Corinth, N. Y., A. B. Copping, International Paper Co., Palmer, N. Y., and George Clossay, Marinette Paper Co., who were invited guests.

Members of the pulp and paper graduating class of the State College of Forestry, Syracuse, N. Y., visiting the Sandy Hill Iron and Brass Works

* * *

Copies of the A B C's of C M P are obtainable from the National Production Authority, U. S. Department of Commerce, Washington, D. C. The basic theory upon which C M P is designed is that three basic metals—steel, copper, and aluminum are the keys to industrial production. If these three materials are allocated to the extent of the available supply and production schedules for manufactured products are set up in harmony with the allotments of the three controlled materials, the other noncontrolled materials will be in sufficient supply to meet these production schedules. Supplies of controlled materials are authorized by an allotment procedure. All other materials necessary to complete the authorized production schedules are to be procured on special DO-Ratings with allotment numbers or symbols.

These DO-Ratings are used only by producers of products in which steel, copper, or aluminum are incorporated and only to the extent needed by them to produce an authorized production schedule.

Following is the ranking in priority: (1) NPA Directive, (2) NPA Allotment, (3) DO with Allotment Number, and (4) DO-Rating.

Special authorization from the NPA is required before any public or private construction project requiring more than 25 tons of steel can be started.

* * *

For the period of October, 1950, through March, 1951, paper and paperboard production was 13,280,000 tons, based on preliminary estimates. This tonnage is almost equal to the production of all of 1939. Production is pushing close to an annual rate of 27 million tons.

* * *

Starting in May the Defense Production Administration issues a weekly bulletin called the Defense Production Record which summarizes orders, regulations, and other activities of the government defense production agencies. Copies may be obtained from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., at $2.50 per year.

* * *

Ernest F. Trotter, Editor of *Printing Magazine* indicated recently that he believes that more paper will be made and sold in rolls in the future, because of the printers' necessity for reducing unit costs by getting the advantages of webbed press speeds.

* * *

The Canadian pulpwood harvest East of the Rockies during the year ending May 31, 1951, totaled more than 12 million cords, a record high, which is about 9% higher than the previous peak in 1947–48.

* * *

The Senate is considering a bill S. 1472, introduced by Senator Kefauver, which would encourage the prevention of water pollution by allowing amounts paid for industrial waste treatment works, as defined in Section 10c of the Water Pollution Control Act, to be amortized at an accelerated rate (60 months) for income tax purposes.

* * *

The second edition of the "Dictionary of Paper" is to be published August 1, 1951. Copies may be purchased from the American Paper and Pulp Association, P. O. Box 498, Appleton, Wis., at $6.50 each.

* * *

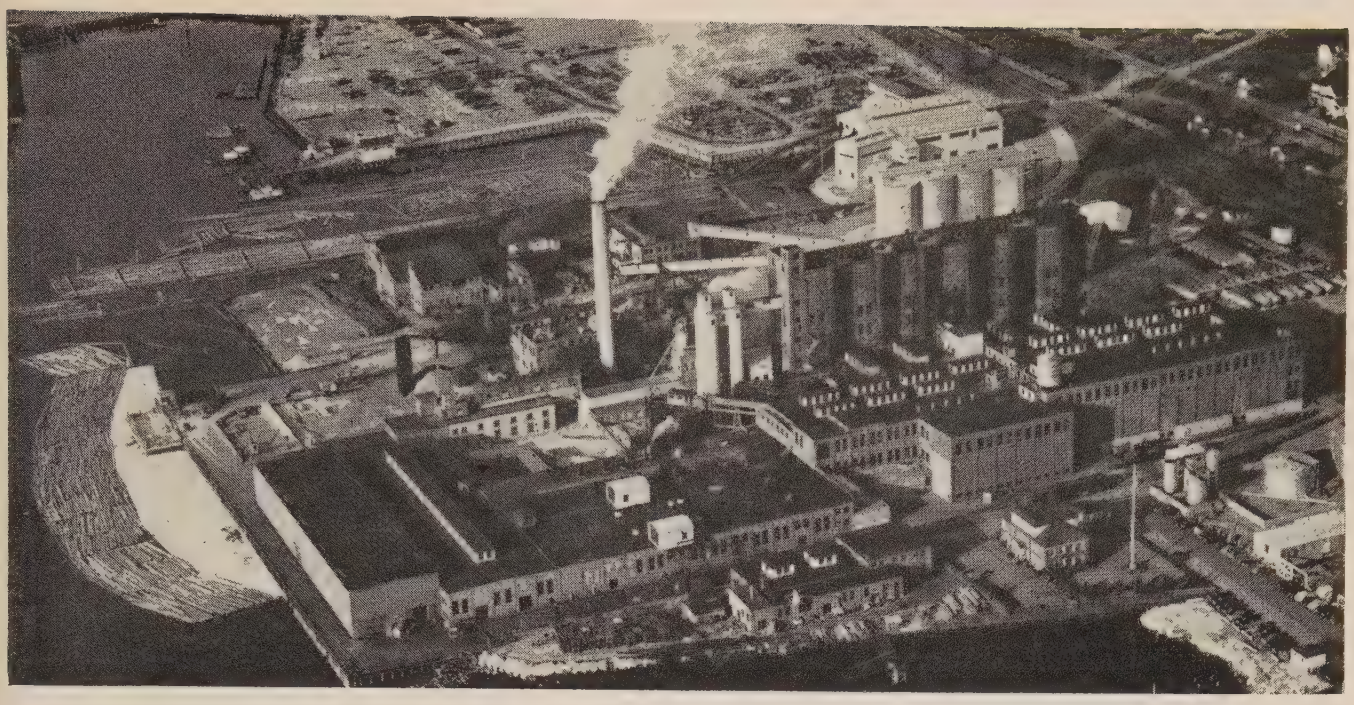
Through May 7, 1951, the pulp and paper industry files 141 applications for certificates of necessity in the amount of 746 million dollars. Applications for 32 have been approved, and although the original request was for 352 million dollars, the applicants were eligible for only 209 million dollars, a 59.4% certification.

* * *

The record March production of domestic wood pulp indicates an annual rate of production of 16,300,000 tons, while waste receipts and consumption were both at high levels. On the basis of recent consumption rates, it will take 17,700,000 tons of wood pulp to make 27,000,000 tons of paper and board. The A.P.P.A. Monthly Statistical Summary points out that this is an amazing record of wood pulp production and it has been the mainstay of the record production of paper and board.

* * *

The 1950 receipts of wood pulp from Europe, in short tons, from countries of origin are as follows: Sweden, 399,320; Finland, 205,881; Norway, 28,957; Russia, 9773; Austria, 20,467; Italy, 551; Czechoslovakia, 2597; France, 120; Germany, 957; Netherlands, 15; Switzerland, 265, Total, 668,903. The total for the first four months of 1951 is 181,169.



SOUNDVIEW PULP COMPANY

EVERETT, WASHINGTON

MANUFACTURERS AND DISTRIBUTORS OF

HIGH GRADE
BLEACHED
SULPHITE PULPS

In 1938 the rates for mailing books was 1.5 cents, the same as for reading matter in the second-class rates. Subsequently the rate on books has been boosted three times. The rate now is 8 cents for the first pound and 4 cents for each additional pound. This compares with magazines which are still at 1.5 cents under second class. Under the recent authorization from the Interstate Commerce Commission for a self-supporting parcel post of the fourth class, it appears that books will be charged at a ten and five rate and even more if a zonal basis is used.

* * *

At the meeting of the National Association of Magazine Publishers, Donald G. Shook, Deputy Director, NPA Forest Products Bureau, indicated that paper supplies for 1951 will be as great as they were in 1950. He pointed out that the NPA is not seeking limitation orders on paper.

A program of reduction in waste in newsprint consumption is the most practical and effective method to avoid placing newsprint under government limitation orders. Advisory committees are studying possible regulations of basis weight limitations but, further meetings will be held before final action is taken on setting weight specifications. The 10% set aside ordered by the government to fill essential government needs has been just about offset by a 10% increase in paper production.

For printers, the ink situation is not too stable because of certain chemical shortages. There is no readily available substitute for resorcinol used in inks. The ink industry claims that it is getting only 40% of the amount it orders of this material.

* * *

Fiber container manufacturers are using the present period to rebuild inventories in anticipation of a heavy fall demand. The production in most areas is on a normal one-shift basis. NPA reports that paperboard production is up 20% over the 1950 rate and estimated that 12,700,000 tons of paperboard will be produced this year. The output of container board this year will be about 6,800,000 tons, or 1,200,000 tons over the 1950 level. Adhesives and tops are in good supply but supplies of stitching wire, of which the industry uses 2000 tons per quarter, are tight.

Representatives of the Quartermaster General, responsible for procurement of containers for all service branches, reports that military needs for fiber containers are being met without difficulty, although occasional shortages of clothing boxes have developed.

* * *

Ninety thousand tons annually of liquid sulphur dioxide will be available to Canadian papermakers when Canadian Industries, Ltd., finishes a plant now being erected at Copper Cliff, Ont., to produce off-gases from International Nickel Co.'s new oxygen flash smelter. The plant is expected to be completed in 1952. The process was developed by C.I.L. in 1932 but was not economic until the Nickel Co.'s oxygen blast, flash smelting process made high concentration stack gases available.

* * *

A grant of $49,867 has been made to the Research Foundation of the State University of New York by Chemical Barking Research Project to investigate chemical treatment of living trees.

Chemical Barking Research Project is a nonprofit organization sponsored by the International Paper Co., Penobscot Chemical Fibre Co., St. Croix Paper Co., American Smelting and Refining Co., P. H. Glatfelter Co., Brown Co., Hollingsworth & Whitney Co., Oxford Paper Co., Eastern Corp., West Virginia Pulp & Paper Co., H. E. Brinkerhoff, and W. S. Bromley of the American Pulpwood Association are Treasurer and Secretary, respectively, of the Project. Work will be carried on at the Adirondack Forest properties of the University for one year.

The general purposes of this study are to ascertain the important factors affecting the loosening of bark of living trees, how these factors affect the tree and the loosening of the bark, the physiological and chemical effects of toxic agents applied to the tree, and the application of data from these fundamental studies to the development of simple, efficient, and controllable techniques in forest operations.

* * *

Analytical measurements, 585 Main St., Chataham, N. J., is marketing a pocket-size pH meter in a plastic case with batteries. The scales read from pH 2 to 12, with claimed accuracy of pH 0.1.

* * *

Production of wood pulp by solvent (triethylene glycol) extraction of lignin from wood is under study by the Weyerhaeuser Timber Co. Early results indicate higher yield than by present methods. Glycol recovery is necessary to make the process economic. The process was discovered by Bror L. Grondal and Piotr Zenczak at the University of Washington and its commercial development is being supervised by Research Corp.

* * *

The Lowell Textile Institute, Lowell, Mass., has established the Lowell Textile Institute Research Foundation to encourage and administer research sponsored by industry and government at the Institute. The foundation personnel and the Institute faculty will jointly constitute a staff available for investigating problems involving physics, chemistry, biology, engineering, and industrial economics in the fields of paper, textiles, leather, and related areas of interest.

* * *

Replacement of old western hemlock and Douglas fir with second growth trees is said by B. T. Briggs, of Rayonier, Inc., research department to result in higher yields in pulp by both unit weight and volume measure. In comparing results of tests with sapwood and heartwood, Dr. Briggs found both at the Forest Products Laboratory and his own laboratory that there was roughly a 5% higher yield of pulp from sapwood than from heartwood by the sulphite process. In the kraft process, the results were about the same. (There is more sapwood in second growth in ratio to heartwood than in old growth.)

* * *

Cementing techniques for Lustrex styrene moldings are described in a 13-page booklet prepared by the Plastics Division, Monsanto Chemical Co., Springfield, Mass. The bulletin pays special attention to types of cements, cement viscosity, methods of application, and precautions where advisable. Also covered are bonding of styrene to such porous surfaces as paper, wood, and cork. Copies of the bulletin are available.

* * *

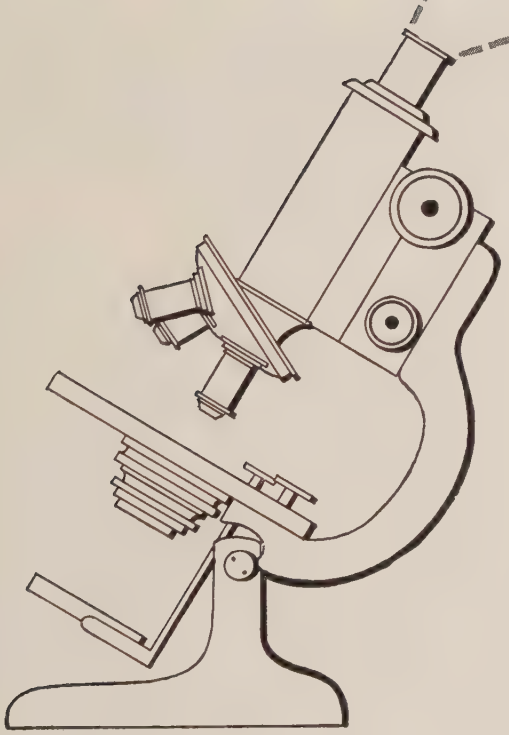
The machinery and equipment of Schorsch & Co., Inc., paper bag manufacturers of Bronx, N. Y., have been acquired by the Equitable Paper Bag Co., Long Island City, N. Y.

* * *

Olin Products Co., Inc., has been organized to distribute Olin Cellophane in the packaging field. James L. Spencer has been appointed Vice-President and Sales Director. Mr. Spencer was formerly with the Industrial Tape Corp., subsidiary of Johnson & Johnson.

kill these pests...

Typical slime-forming organisms



with CHLORINATION by W&T

Quality conscious paper mill superintendents know from experience that chlorination, engineered to their stock or white water requirements by Wallace & Tiernan, effectively eliminates such slime-induced troubles as pin holes, slime spots, and poor sheet formation.

Such results—which have saved up to 400 dollars per day in many mills—are possible because chlorination kills the organisms that *cause* slime. It may be used alone on the fresh water supply, or together with chloramines or other corrective chemicals on the white water, for effective slime control in such key spots as the showers, screens, deckers, and at many other points.

Wallace & Tiernan Chlorinators are particularly effective in slime control work because they are especially designed from over 35 years' experience to give low cost, efficient performance.

For a survey on the chlorination needs of your mill without obligation, call your nearest W & T Representative now and start your plant on the road to slime free operation.

WALLACE & TIERNAN COMPANY, INC.

CHLORINE AND CHEMICAL CONTROL EQUIPMENT

NEWARK 1, NEW JERSEY • REPRESENTED IN PRINCIPAL CITIES

I-36

The five greatest receptions in terms of the weight of paper dropped in the New York City canyons are as follows: General Douglas MacArthur (April 20, 1951), 3249 tons; Douglas Corrigan (Aug. 5, 1938), 1850 tons; Howard Hughes (July 15, 1938), 1800 tons; Charles A. Lindberg (June 13, 1927), 1750 tons; and the American Legion parade (Aug. 30, 1947), 985 tons.

* * *

Several organization changes have been made in the Sandy Hill Iron & Brass Works, Hudson Falls, N. Y. O. John Mills, formerly Sales Manager, is now Assistant to the President. J. Walter Juckett is General Manager. Nils Klykken, who came from Kamyr A/B in Oslo in April, is Manager of the Pulp Machinery Division. Foster P. Doane is Asst. Vice-President. John W. Crocker is Chief Engineer. W. O. Hisey has been named Vice-President. Loren G. Gallup is Asst. Vice-President. George E. Clink is now Sales Manager and Associate Chief Engineer.

O. John Mills, Sandy Hill Iron and Brass Works

Joseph Morningstar, Morningstar-Nicol, Inc.

* * *

Morningstar-Nicol, Inc., manufacturers of starches, dextrines, and adhesives opened its 100th Anniversary year on May 1. Joseph Morningstar succeeded his father as President in 1916. Under his management Paisley Products, Inc., was established in 1930, and in 1938 Aroostook Potato Products was founded at Houlton, Me. Associated with Mr. Morningstar are his two brothers, Robert P. and Thomas, and one nephew Joe Barry Morningstar. To mark the 100th Anniversary the company has put into effect a profit-sharing plan to benefit all employees with two or more years of continuous service.

* * *

Fred C. Boyce was re-elected to serve his 18th consecutive year as President of the D. J. Murray Mfg. Co., Wausau, Wis. A. W. Plier was elected Vice-President and General Manager. The company has 375 employees.

* * *

R. E. Greenfied, General Superintendent of A. E. Staley Manufacturing Co. since 1946, has been elected Vice-President in charge of manufacturing operations.

* * *

Johns-Manville Corp., 22 East 40th St., New York 16, N. Y., has issued a 4-page folder on Super Block Insulation for light-temperature insulation.

* * *

National Starch Products, Inc., 270 Madison Ave., New York 16, N. Y., has issued a leaflet entitled "The Amazing Versatility of Starch for Paper Making."

Infilco, Inc., manufacturers of waste and sewage treating equipment has completed the removal of its executive and engineering offices from Chicago to Tucson, Ariz. Infilco's factories and laboratories remain at Chicago.

* * *

G. D. Jenssen Co., Inc., has announced that A. H. Lundberg of Seattle, Wash., has resigned as West Coast representative of the company. All company business will be handled directly from the head office of the company in Watertown, N. Y. It is expected that a new West Coast representative will be named soon.

* * *

Leland H. Burt has been named supervisor of product development for the Cellulose Products Department of Hercules Powder Co. He has been supervisor of C M C development for the past two years. In his new position he will devote his efforts to various water-soluble products, including cellulose gum (C M C), on which he has been specializing during his association with Hercules.

* * *

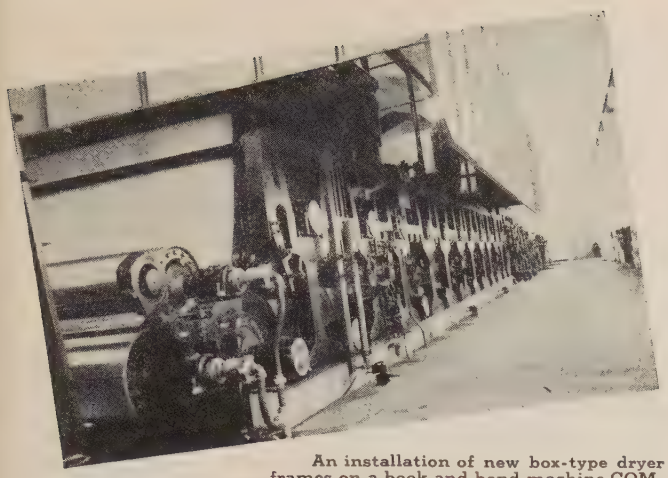
The Hauser-Stander Tank Co., Cincinnati, Ohio, has distributed a very interesting booklet "This Great Age," which deals with the use of wood in making tanks. The booklet was prepared by the National Wood Tank Institute of Chicago.

* * *

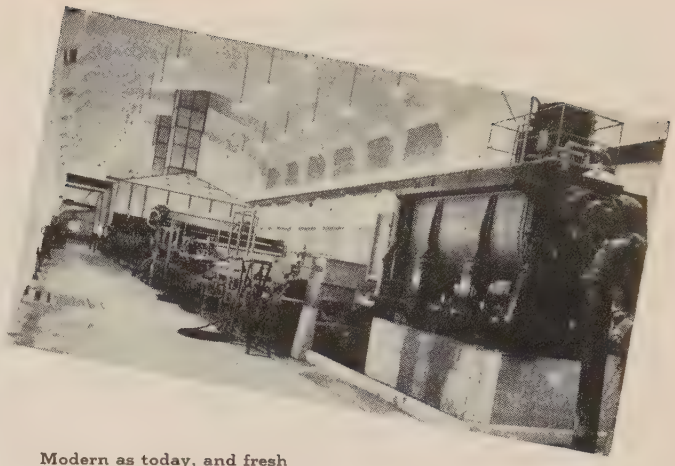
J. M. Huber Corp. is now shipping paper coating and filler clays in shipping sacks that have been deaerated. After passing through Huber's deaerating equipment, the clay bags are

Unit loads make Huber clay shipments easy to handle and cut down freight car handling time

normally stacked in unit loads of 3000 pounds on fiberboard sheets, with bags held in place by adhesives. Freight cars are loaded at Huber plants in patterns best suited to the customer's unloading facilities. Field reports indicate that shipments arrive in excellent conditions and that deaeration saves about 20% in storage space.

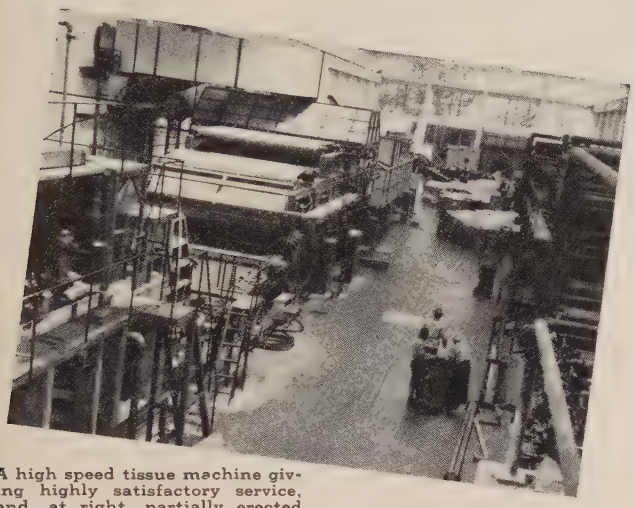


An installation of new box-type dryer frames on a book and bond machine COMPLETELY SANDY HILL DESIGNED AND BUILT.

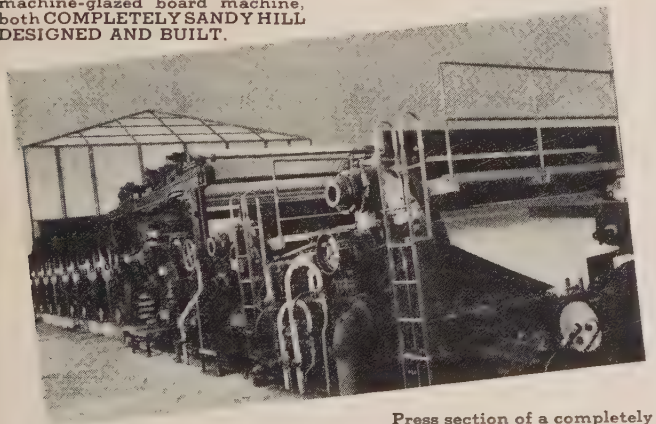


Modern as today, and fresh from Sandy Hill drafting boards is this machine, operating on high grade specialties COMPLETELY SANDY HILL DESIGNED AND BUILT.

Completely Designed and Built by *Sandy Hill*



A high speed tissue machine giving highly satisfactory service, and, at right, partially erected machine-glazed board machine, both COMPLETELY SANDY HILL DESIGNED AND BUILT.



Press section of a completely new machine recently put in operation. COMPLETELY SANDY HILL DESIGNED AND BUILT.

PRODUCING good papers week after week in many large and small mills throughout the industry are COMPLETE paper machines DESIGNED AND BUILT BY SANDY HILL.

These machines and their superlative records for continuous trouble-free operation, are evidence of the established importance of Sandy Hill in the industry.

Another gratifying indication that Sandy Hill is doing a real job is the growth of the Sandy Hill organization. Today Sandy Hill's personnel of experienced engineers and skilled craftsmen numbers ten times what it did only 15 years ago.

When you start to plan changes in your mill, then is the time a Sandy Hill sales-engineer can be of great service whether it be a complete machine or a minor piece of specialty equipment.

Sandy Hill's new Brochure of Pulp and Paper Making Machinery is available on request

Sandy Hill Iron & Brass Works

Hudson Falls, N. Y.

Machinists and Founders Specializing in Paper and Pulp Mill Machinery

Manufacturers of
Adjustable Cylinder Vats
Cylinder Paper Machines
Pulp Grinders
Dandy Roll Drives
Pulpers or Kneaders, Voith
Thickeners
Quick Opening Gate Valves
Bertrams Flow Distributors
Bertrams Shakes
Neilson Slice
Feltless Wet Machines
"Selective" and Corner Drives
Fourdrinier Paper Machines
"Packer" Screens
Castings
Bleaching Equipment
Scofield Felt Conditioners
Cleveland Type Bearings
Shaker Screens

In drilling for petroleum, producers have to use large quantities of semifluid special needs to carry away drill cuttings to keep the drill bit from overheating and to seal off any geological faults in the rock deep down in the hole.

The sulphite waste liquor by-product, which the Marathon Corp. markets, is a dispersant—a chemical that keeps the mud at the desired consistency. A major advantage claimed is that this material does not break down under the heat and pressure often found in deep drillings. Up to half a box car of the material is sometimes required for a deep well.

* * *

A Power Factor Visualizer (SA-6739) that presents a simple explanation of the use of capacitors in solving low power factor problems is available from the Westinghouse Electric Corp., Box 2099, Pittsburgh 30, Pa. It is prepared in the form of a slide rule type chart and makes it possible to follow a hypothetical case involving low power factor and shows how the installation of capacitors can solve this. Capacitors provide greater capacity from existing electrical systems; better voltage conditions; improved motor performance through increased voltage; lower current and reduced line losses; decreased transformer losses, and more effective use of lighting equipment through higher voltage.

Westinghouse also has issued a new Industrial Lighting booklet (B-4727).

* * *

The Philadelphia Quartz Co., Public Ledger Bldg., Philadelphia 6, Pa., is celebrating 120 years of continuous business. In July, 1831, Joseph Elkinton opened a soap and candle factory in Philadelphia. In 1858 he experimented in the use of silicate of soda in soap manufacture and found that the washing action was improved. In 1864 a large factory was built in Philadelphia to manufacture silicates and the Philadelphia Quartz Co. was established to supply these products to other soap manufacturers. At the beginning of the century the acceptance of the corrugated box as a shipping container resulted in utilizing silicates as adhesives. This led to the building of a new plant in Chester, Pa., to make silicate of soda.

* * *

Tests recently completed by Consolidated Water Power and Paper Co. at its Biron mill may bring the sulphite pulp industry a step closer to its conservation goal of reducing stream pollution from spent liquor.

The purpose of the tests was to learn whether sulphite liquor can be effectively pressed out of pulp instead of being washed out. Technical men and engineers are now trying to find practical ways of using what these experiments showed.

Collecting the spent liquor for treatment is the first step in any process to cut pollution. Sugar in the liquor is what harms fish, so the problem is to collect the most sugar and the least water. If a mill can collect a larger share of its spent liquor at full strength, it can cut pollution that much more effectively.

When sulphite pulp comes from the digester process, the spent liquor that it contains is normally allowed to drain. Then the liquor remaining in the pulp is washed out with water. When the wash water becomes too dilute for effective processing, it can no longer be collected and has to be flowed to the stream.

In the recent Biron tests, sulphite pulp made at Consolidated's sulphite mill here was put through some large presses that are part of another process. After all the liquor possible has been pressed out at full digester strength, the sulphite pulp has to be diluted with water and washed to get out the remaining liquor. This added step uses up time and costs.

Results of the Biron tests show that by pressing, it is possible to collect a higher percentage of the sugars and other solids with a minimum of water. Consolidated's technical staff is now trying to devise ways that will permit using the pressure-extraction method at costs that will not be excessive.

* * *

May, 1951, was the Fiftieth Anniversary of the Samuel M. Langston Co. There were a number of celebrations in honor of this occasion but the largest was the Open House, Sunday, May 20. This Open House was for the employees, their families and friends. With employment at an all-time high of

"Open House," May 20, 1951, Samuel M. Langston Co., Camden, N. J.

351, about 307 employees attended, with a total attendance of 1410. It made it possible for the employees to show their families where they work, what they do, and the types of machinery the company builds. For those who attended the last Open House there was the opportunity to see the additions to plant and office that have been made in the last few years.

* * *

The Grasselli Division of du Pont has developed a product called Quilon, a stearate chronic chloride. It can be used in the manufacture of water-repellent paper for low-cost wrappings such as for ice and fresh vegetables and poster paper for outdoor signs. One pound of Quilon will produce a strip of water-repellent paper 3 feet wide and a mile long.

* * *

A new double-row tree planter designed and built by Nekoosa-Edwards Paper Co. is now operating in the company's central Wisconsin timber holdings. It is shown in the accompanying photograph planting trees near Big Flat in Adams County.

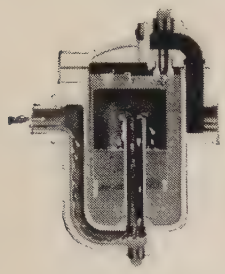
Outstanding feature of the new machine is that it plants two rows of trees at the same time whereas other standard tree planting machines are designed to set out only one row at a time. In designing and building the machine, Nepco forestry crews made use of two standard Lowther planting rigs mounted side by side on the rear of an International TD6 cat-type tractor.

Another important advantage results from mounting the device in such a manner that the entire mechanism and planting crew can be instantly elevated by hydraulic jacks for speed and efficiency in turning around at the end of the field. Other standard planters operate on a trailer principle and require more time and room for the wide arc in turning around.

On the first eight-hour trial run of the new planter, 24,000

ARMSTRONG PRODUCTS FOR BETTER PAPER MILL PERFORMANCE

SPECIAL TRAPS FOR DRYER DRAINAGE



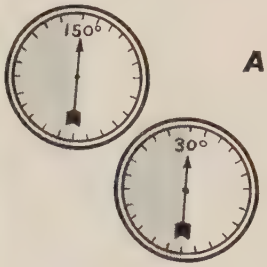
Better Performance,
Low First Cost,
Low Maintenance.

USE of an individual Armstrong trap on each paper machine dryer insures quick removal of condensate, air and incondensible gases at any pressure, provides higher operating temperatures. The cost is far less than for more elaborate systems and the special new Armstrong paper machine trap gives you long life with low maintenance. Quality is guaranteed.

BULLETIN NO. 205 ➧

. . . explains why you can depend on Armstrong paper machine trap performance. Send for a copy.

INDIVIDUAL DRYER TEMPERATURE CONTROL FOR PAPER MACHINES



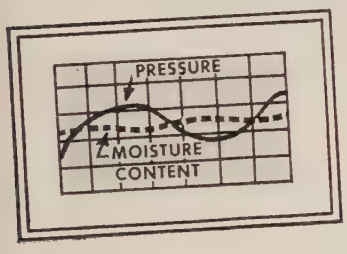
Automatically maintains dryer temperature at any point from 100°F to 250°F

THIS control mixes air with steam to maintain relatively cool wet end dryers. This prevents the sheet from sticking to the dryer surface and avoids curl or cockle due to overdrying on one side. The rest of the machine operates at maximum temperature.

BULLETIN NO. 187 ➧

. . . explains the Control and its advantages. Write for a free copy.

MOISTURE CONTROL SYSTEM FOR PAPER MACHINES



Automatically maintains very uniform sheet moisture content at any desired percent

THIS control maintains much more accurate sheet moisture content than is possible with hand control or constant steam pressure. It detects moisture content changes as the sheet passes over an "indicating dryer" and then varies steam pressure on the entire machine to compensate for the moisture variation.

BULLETIN NO. 196 ➧

. . . tells how the Moisture Control works, explains the specially designed components, lists the advantages. Send for your copy.

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BULLETIN NO. 1772 ➧

. . . discusses relative humidity, gives data and prices on Armstrong Humidifiers, explains hookups, selection, etc. Send for your copy.

ARMSTRONG MACHINE WORKS

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trees were set out. This nearly doubles the number usually planted with single-row models. When the crew becomes better familiarized with the new machine, it is expected that the planting rate will be further increased.

The new machine will enable Nepco foresters to plant more trees at a lower cost. Two single-row planters require two tractors and six men for planting. It is expected that four men and one tractor can accomplish the same job with the new planter.

The new Nekoosa Edwards tree planter

Several years ago, the first single-row tree planting machines were developed and tested on Nekoosa-Edwards lands. The new machine is another example of the technical progress that enables Nekoosa-Edwards to expand its reforestation efforts year-by-year to a point where this year the company expects to field plant 800,000 pines and make 500,000 more available free of charge to central Wisconsin land-owners. The company grows its own planting stock from seed in its forestry nurseries.

Of more than 110,000 acres of land under the company's forestry management, approximately 50,000 acres are in central Wisconsin, including nearly 18,000 acres that have been field planted since the company began its forestry program nearly 27 years ago.

Memorandum Concerning Sulphur

The Sulphur Committee of the International Materials Conference has forwarded its report to member governments. The salient features of this report are that in 1951 the sulphur committee expects that requirements for native sulphur will exceed supply by at least one million tons. This shortage may be intensified as the demand for sulphur increases. Suggested ways for increasing supplies of native sulphur include:

1. Increased production of pyrites and increased use thereof in the manufacture of sulphuric acid.
2. Increased use of waste smelter (roaster) and industrial gases.
3. Expansion of the use of raw materials such as anhydrite and gypsum in the manufacture of sulphuric acid and ammonium sulphate.

"The measures outlined above will not provide a remedy for the immediate shortage and the Committee is considering methods of effective distribution of available supplies of sulphur."

The Committee recommends that:

1. Every country should make a critical examination of its resources of sulphur and sulphur-bearing materials and develop them to the maximum extent practicable, especially for the production of sulphuric acid.
2. Those countries which have no resources of sulphur and sulphur-bearing materials or whose resources are small should examine the possibility of obtaining raw materials other than sulphur from elsewhere and of using them as far as practicable, especially in the manufacture of sulphuric acid.
3. Conservation in the use of sulphur should be practiced wherever possible.
4. Where it has not been done already control of the use of sulphur should be instituted so that it will not be used wastefully or for nonessential purposes.
5. Since, in certain countries, the earliest possible completion of projects for the production of pyrites and for the use of pyrites as a source of sulphur is desirable, countries supplying plant and equipment for such purposes should facilitate its manufacture and delivery.
6. To assist the Committee in the continuation of its work, each country should furnish to the Committee not later than October 31, 1951, a report indicating the progress made in implementing any or all of the recommendations in 1, 2, 3, and 4.

Further comments in the report are:

"Sulphur or its principal compounds—sulphuric acid, sulphur dioxide, and carbon bisulphide—are essential in most industries and are of high defense importance. Examination of statistics reveals that since 1949 demand for sulphur, as such, has increased by 32%. This increase is due to expansion in the use of sulphuric acid for super-phosphate, ammonium sulphate, textiles, dyestuffs, metallurgical and other uses; sulphur dioxide for wood pulp; carbon bisulphide, mostly for rayon; agriculture for dusts, insecticides, etc.; industry for rubber, dyestuffs, explosives, food processing, etc.

"Sulphuric acid is the predominant consumer of sulphur. Statistics available to the Committee, though incomplete, reveal that in 1939 approximately half the sulphuric acid produced in the world was made from pyrites and approximately 35% from native sulphur. In 1949 the percentage of these materials used in making acid has been reversed.

"This position developed because sulphur of high purity from salt domes in Texas and Louisiana became available in large quantities at a price which, generally speaking, made it the most attractive source of sulphur for many countries. The Committee's inquiries reveal, however, that production of sulphur from the United States is not keeping pace with demand and that the known reserves of sulphur in these domes are not large enough to meet world demand at current levels."

From the above report it is apparent that the low price of the native sulphur produced in the United States as compared with the sulphur derived from pyrite has practically driven pyrite produced sulphur from a large segment of the international market so that U. S. produced native sulphur has become an international commodity in short supply.

Facts About the Sulphur Shortage

Sulphur is in short supply for the first time since World War I. The shortage is threatening to affect many products, among them newsprint. This memorandum, prepared by Freeport Sulphur Co. to provide basic facts about the situation, covers the following:

Despite the fact that U. S. production of brimstone (the principal form of sulphur in America) has increased 146% since the prewar years 1935–39, there is for the first time since World War I a shortage of sulphur. The impact of the shortage has brought the element, long taken for granted, into the national and international spotlight.

The shortage first began to be felt in the latter half of 1950. For 1950 as a whole, U. S. brimstone production was 5,350,000 long tons compared to total sales of 5,700,000 (4,259,000 domestic and 1,441,000 foreign including Canada). The difference of 350,000 tons—or $6^1/_2$%—was made up by withdrawals from stocks of sulphur previously mined.

The shortage in 1951 is expected to be substantially greater than that of 1950. Not only is the demand higher but the supply will be less because further withdrawals from stocks should not be made. These stockpiles have fallen from a two-

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year reserve before World War II to a 6 months' supply in January, 1951, a minimum requirement. Current needs therefore will have to be met from current production.

In this situation various measures are being taken to distribute the available supply of sulphur on a fair and equitable basis. In accordance with our nation's international policy of strengthening our Allies abroad, our Government has directed American brimstone companies to allocate substantial tonnages of sulphur for shipment overseas. (So far, for allocation purposes, Canada is considered to be part of the domestic market.) The quotas for the first half of 1951 amounted to 86% of the first 6 months' exports abroad in 1950. The final amount for the second half of 1951 has not been determined.

The Government has under consideration plans to allocate sulphur in the domestic market but up to now has left such a task to brimstone producers. Freeport Sulphur Co., for example, is allocating on the basis of 85% of sulphur purchased in the base period of Oct. 1, 1949 to Sept. 30, 1950. Special allowances are made for hardship cases due to plant expansion, strikes in the base period, etc., and these have the effect of increasing the over-all allocation above 85% of actual purchases in the base period. Under the Freeport plan all customers, regardless of the industry to which they belong, are treated on exactly the same basis.

The principal reasons for the shortage are: (1) greater demands from abroad, (2) a disproportionate increase in domestic requirements, (3) the low price of brimstone which has tended to discourage development of higher-cost sources, and (4) the difficulty of finding new brimstone deposits.

The greater demand from abroad is due to the failure of foreign sources to recover from the disruption of war and to the fact that U. S. sulphur is cheaper and purer than foreign sulphur. These and other factors have led foreign sulphuric acid makers in many instances to choose brimstone instead of pyrites as their source of sulphur when rebuilding war-damaged acid plants or constructing new plants. As a result of these and other developments, exports of U. S. brimstone to all countries including Canada were 155% higher in 1950 than were average annual exports in 1935–39.

The increase in the demand for sulphur by U. S. industry and agriculture has been of a much greater proportion than the increase in general industrial activity. Shipments of brimstone to U. S. consumers in 1950 were 180% above the average shipments in 1935–39 while general industrial production was up 100%. These increased domestic shipments of sulphur were brought about primarily by the expanded requirements of large sulphur-consuming industries. For instance, the per capita consumption of fertilizer, chemicals, and rayon and cellulose film in 1950 was almost three times the average for 1935–39. The average per capita consumption of sulphur for 1935–39 was 35 lb.; in 1950 it was 75 lb.

Practically all U. S. brimstone is now being sold to domestic users at a price at the mine of $21 to $22 per long ton. Sales of sulphur from foreign sources have been made recently at prices as high as $75 to $100 per ton. The $21 to $22 domestic price reflects an increase of about 25% over prewar (1935–39) prices as compared with an increase of 100% for wholesale commodity prices, as reported by the Bureau of Labor Statistics. It is also comparable to an increase of 61% for iron ore; 103% for bituminous coal; 141% for crude petroleum.

The per ton price of brimstone is equivalent to about 1¢ a pound. Brimstone therefore is the cheapest of all the elements. Its price contrasts with 50½¢ a pound for nickel; 19¢ for aluminum; 24½¢ for copper; 17¢ for lead; and 17½¢ for zinc.

Brimstone producers for many years have spent large sums of money searching for new deposits of sulphur, but successful explorations are rare. Salt domes are located exclusively along the Gulf Coast. Of over 200 such domes discovered, sulphur has been mined from only twelve and five of these have already been exhausted. The cost of prospecting and developing new mines has increased tremendously. Moreover, the risk involved is very great because the complete plant supplying hot water and compressed air must be built at the new location before it can be determined whether or not sulphur can be mined successfully in commercial quantities.

In considering the long range as well as the immediate outlook, it must be borne in mind first that sulphur is one of the most common and widely used of the elements. It occurs in the earth in various forms, and it is obtained commercially from many sources throughout the world.

The most important source in the United States is the so-called salt dome deposits of native sulphur, or brimstone, located along the Gulf Coast. The next most important source is pyrites, which is an inclusive name for the metallic sulphides found in many states and in many foreign countries. Other sources are deposits of brimstone not of salt dome origin; hydrogen sulphide in sour natural gas and in oil refinery gas; sulphur dioxide at smelters; and sulphate minerals, such as gypsum.

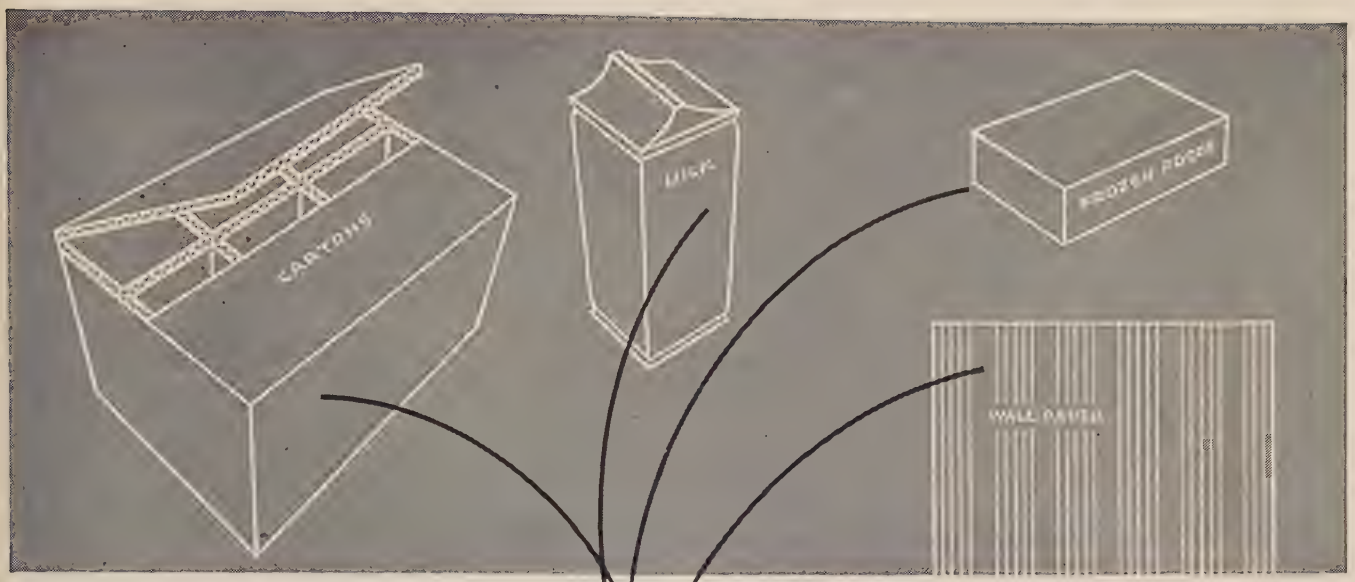
The efforts to solve the shortage therefore involve not only brimstone but other sulphur sources. On the brimstone front several projects by brimstone producers are now under way. Texas Gulf Sulphur Co. is constructing a new sulphur mining plant at Spindletop dome in Texas and Jefferson Lake Sulphur Co. at Starks dome in Louisiana. Freeport Sulphur Co. has begun work on a new plant at Bay Ste. Elaine dome in Louisiana. These three mines, however, are expected to be relatively small. Moreover, production at some of the older mines is expected to decline as they approach depletion.

Unless new discoveries of large brimstone deposits are made, which of course cannot be counted on, the solution to the sulphur shortage lies primarily in the development of production from other sources of sulphur. Sulphur industry members believe that the key to unlock this production is price. Most of this production would be relatively high cost, but the reserves of sulphur that could be obtained from these sources are vast. Although the present economic controls in the national defense effort prevent an increase to restore the normal balance between demand and supply, sulphur industry members foresee an eventual increase in order to provide the impetus for greater sulphur production from the various sources.

The production of sulphur in the United States has undergone a radical change in the last 50 years. Before the turn of the century this country was almost completely dependent on foreign sources for sulphur. Brimstone was imported from Sicily and Italy and pyrites from Spain. Even as late as the first World War, the United States imported a third of its sulphur requirements.

Brimstone was known to exist in this country prior to 1900, but its location under several hundred feet of unstable marshland prevented its being mined by existing methods until the invention of the Frasch process. This process is based on the fact that sulphur has a relatively low melting point. Superheated water, pumped down wells, melts the sulphur, which is then forced to the surface by compressed air. The molten sulphur cools and solidifies in storage vats, which are later broken down for shipment.

In 1950, 90% of the total domestic supply of sulphur came from the salt dome brimstone deposits located along the Gulf Coast in Louisiana and Texas. These mines are operating at top capacity. There are four principal companies mining brimstone in this area: (1) Texas Gulf Sulphur Co., with mines at Boling and Moss Bluff domes in Texas, (2) Freeport Sulphur Co., with mines at Hoskins Mound dome in Texas and Grande Ecaille dome in Louisiana, (3) Duval Sulphur & Potash Co., with a mine at Orchard dome in Texas, (4) Jefferson Lake Sulphur Co., with mines at Long Point and Clemens domes in Texas. Six companies produce brimstone from sour gas and sour oil, and about 50 other companies obtain sulphur in one or another form from pyrites deposits, smelter gases, and other sources.



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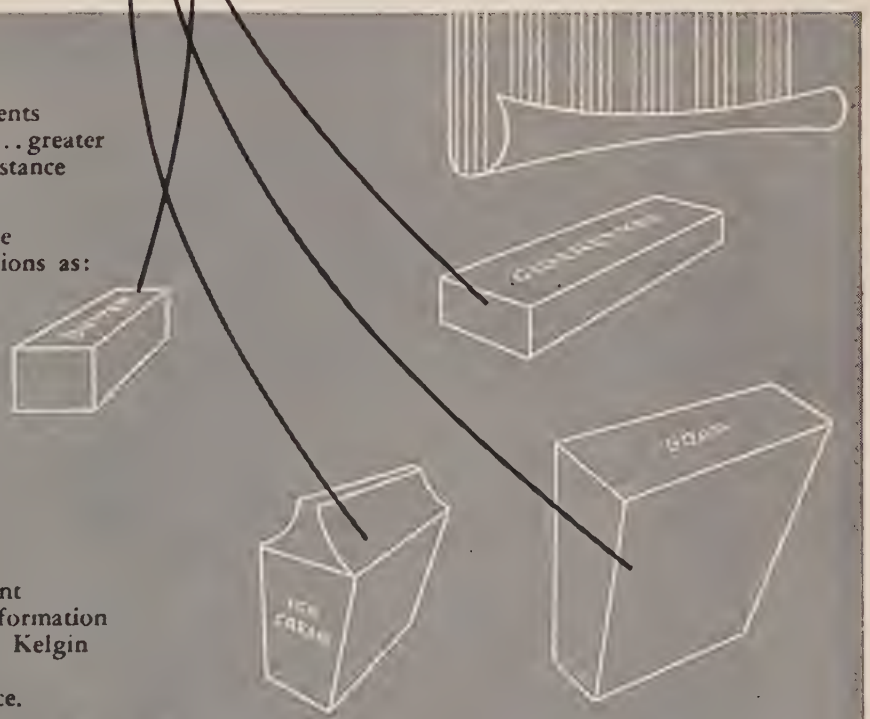

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U. S. brimstone production in 1950 was 146% above the 1935–39 average. General industrial production, as measured by the Federal Reserve Board Index was 100% higher than the 1935–39 rate. Production of minerals, as measured by the Federal Reserve Board, was up 50%.

The U. S. production of sulphur by sources in long tons:

	1900	%	*1935–39 av.*	%	*1950*	%
Brimstone	3,000	4	2,175,000	84	5,350,000	90
Pyrites (contained sulphur)	82,000	96	222,000	9	391,000	6
Other sources	None	...	172,000	7	225,000	4
	85,000	100	2,569,000	100	5,966,000	100

Exports and imports of sulphur in various forms in long tons:

	1900	*1935–39 av.*	*1950*
Exports			
Brimstone	None	566,000	1,441,000
All other sources	None	None	None
Imports			
Brimstone	168,000	3,000	None
Pyrites (contained sulphur)	180,000	195,000	100,000

In contrast to the situation in the United States, the most important source of sulphur for the world as a whole has traditionally been pyrites. Before World War II, pyrites supplied over half of the world total from all sources.

In this last decade of accelerated growth by the brimstone industry, pyrites and other sulphur sources, however, have made little progress. This has been due mainly to two factors. In the first place, World War II and the subsequent economic instability disrupted foreign sulphur sources severely and they have not been able to recover their prewar position. Secondly, the low price and high quality (better than 99% pure) of U. S. brimstone placed it in a preferred position in the world market. The result has been that the U. S. brimstone industry is now supplying a far greater share of the world total. Last year it accounted for 46% of the world's sulphur supply as compared to 26 to 28% before the war.

The estimated world supply of sulphur from all sources by countries:

Country	*1935–39 av., long tons*	%	*1950, long tons*	%
United States	2,569,000[a]	31	5,966,000[a]	51
Japan	1,093,000	13	859,000	7
Italy	738,000	9	628,000	5
Spain	1,116,000	14	558,000	5
Norway	418,000	5	311,000	3
Portugal	195,000	2	295,000	3
Cyprus	173,000	2	289,000	3
Subtotal	6,302,000	76	8,906,000	77
Other 26 countries	1,898,000	24	2,794,000	23
Total	8,200,000	100	11,700,000	100

Between the 1935–39 period and 1950:

U. S. sulphur production (all sources) increased 134%
U. S. brimstone production increased 146%
Foreign sulphur production (all sources) increased..... 2%

[a] In 1935–39, 85% represented brimstone; in 1950, 90% represented brimstone.

Sulphur in one way or another enters into the manufacture or processing of nearly every industrial product. In the initial stage of consumption, the sulphur generally is converted into a secondary product, the most common being sulphuric acid. In the next step, the sulphur in the form of acid or in other forms is utilized by the end-use industry. These industries and the amount of sulphur they consumed in 1950 are:

Industry	*Long tons (2240 pounds)*	% *(approx.)*
Fertilizers	1,665,000	34
Chemicals and miscellaneous	1,200,000	24
Petroleum	472,000	10
Pulp and paper	375,000	7
Rayon and cellulose film	365,000	7
Paints and pigments	307,000	6
Iron and steel	196,000	4
Insecticides and fungicides	140,000	3
Other metallurgical	110,000	2
Rubber	75,000	2
Industrial explosives	41,000	1
Total	4,946,000	100%

In the final step, the products of many of these industries contribute in turn to countless other articles, such as foodstuffs, soaps and detergents, clothing, gasoline and lubricants, newspapers and magazines, containers, automobiles and airplanes, construction materials, tires and tubes. This list could be expanded to include almost everything we eat, wear, or use. The amount of sulphur going into the different products varies widely from product to product. Representative sulphur requirements of a few typical products are approximately:

37½	pounds for each ton of newsprint
1	pound for each pound of viscose rayon
174	pounds for each ton of 3-8-3 fertilizer (a typical mixture)
⅖	pound for refining each barrel of crude oil
18	pounds for each ton of steel
65	pounds for each ton of rubber
35	pounds for the average automobile

* * *

A Paper and Board Packaging Mission sponsored by the Economic Cooperation Administration visited the Experiment Station of Hercules Powder Co., May 18. The visitors are shown here, with Hercules men, on the steps of the Country Club at the Experiment Station. From left to right, front row, they are: M. M. Bixby and K. Holzheuer, Hercules; Karsten Grip Blom, Denmark; Svend-Aage Georg Hviid, Denmark; Samuel C. Stovall, Department of Commerce; Herve Lacaux, France; Dr. Wolfgang Reinthaller, Austria; Victor Henoumont, Belgium; and P. F. Neumann, Hercules.

Second row, left to right, are: D. D. Cameron, Hercules; Henri Felten, France; Dr. Julius Herrmann, Germany; William Stabernack, Germany; Werner H. K. Peters, Germany; Oreste Athanassoula, Greece; and D. M. Houston, Hercules.

Third row, left to right, are: Dr. J. H. Long, Dr. W. D. Thompson, and R. Rockwell, Hercules; Guy Derreumaux, France; Verner Andersen, Denmark; Frederick Pitman Dagnall, Ireland; Hans Kruger, Germany; J. H. deWilde, Hercules; Simon Wieser, Austria; H. C. Phillips, Hercules; Roger Pi, France; P. W. Meyeringh, Hercules; and Omer Saels, Belgium.

E.D. Jones

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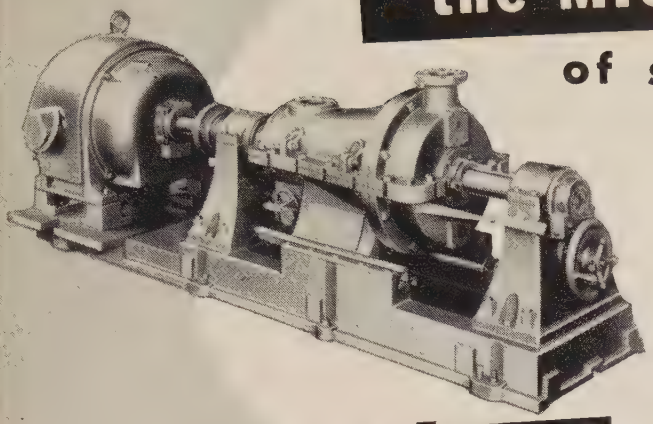

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Rotor of No. 4 size Jones Pulp-Master, shown in tile tank installation in a leading midwestern mill. Capacity 4000 lbs. 6½% stock.

E.D. Jones

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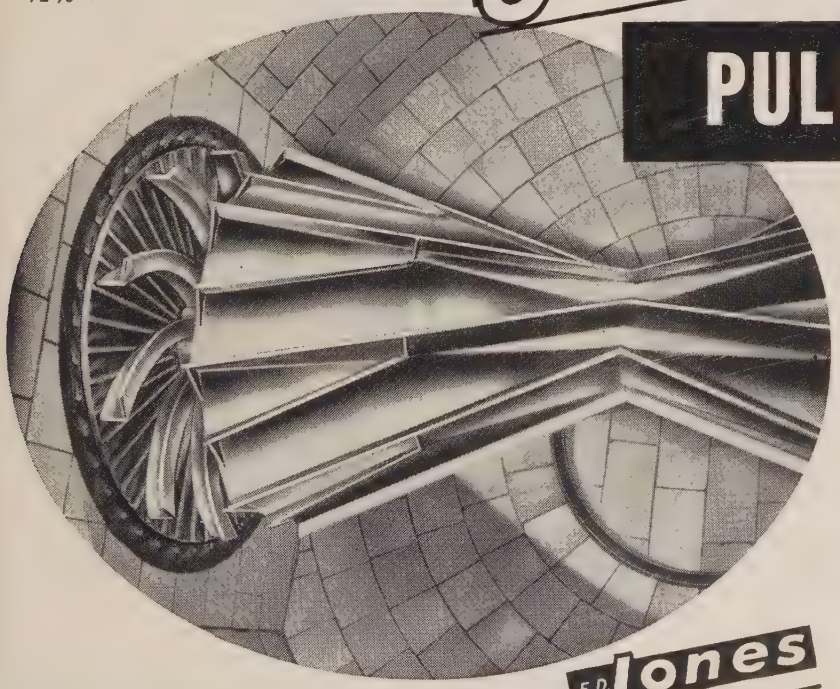

The rugged, one-piece fabricated rotor of the PULP-MASTER, placed well above the bottom of the tank, gives stock vigorous, continuous circulation — yet allows junk metal to drop to the tank bottom.

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LOCAL SECTION ACTIVITIES

Reports of Meetings, Personnel and Events

Delaware Valley

The Delaware Valley Section met at the Engineers Club, Philadelphia, Pa., on Thursday, May 24. A. S. Erspamer of The P. H. Glatfelter Co., Spring Grove presided as Section Chairman. Dr. Erspamer introduced W. R. Willets, newly elected Chairman of the Metropolitan District of the Empire State Section.

R. G. Macdonald, National Secretary-Treasurer of TAPPI was present and gave a brief account of the events leading to the formation of the Delaware Valley Section. In doing so he pointed out that the initial proposal for such an organization came from Charles W. Rivise of Caesar & Rivise, Philadelphia patent attorneys.

Edward J. Albert of Thwing-Albert Instrument Co., Philadelphia, Pa., commented on the recent untimely death of Mr. Rivise in an airplane collision, off Key West, Fla., and presented the following resolution which was adopted, with a period of silent meditation.

WHEREAS, in the workings of Providence, our co-worker, Charles W. Rivise, was suddenly taken from our midst, and

WHEREAS, Mr. Rivise was one of those instrumental in organizing the Delaware Valley Section of TAPPI and was active in its affairs since then as well as in those of our parent body; therefore

Be it Resolved, that we hereby express our deep sorrow at the passing of a friend and fellow-member. Mr. Rivise's death has taken from us a wise counselor, an able negotiator, and a friendly companion.

Be it further Resolved, that this resolution be entered on the minutes of this meeting.

The speaker of the evening was M. A. Hescock of the Brown Co., New York City, who discussed "Dissolving and Specialty Woodpulps." Mr. Hescock preceded his talk by the showing of the Brown Co. film, "Timber is a Crop." His remarks follow:

Dissolving and Specialty Pulps

"You have just been shown the methods used in harvesting the raw material to be used in the manufacture of pure wood cellulose; before continuing with a description of the processing of the wood to the refined product, a short résumé of the history of the development of the manufacturing processes is in order.

"Originally cellulose was used as produced in nature with only the simplest of modifications. The seed hairs of the cotton plant were twisted into yarn and woven into cloth. With the aid of fermentation, the bast fibers of the flax plant were separated and converted into textile linen. Trees were cut into lumber or used for fuel. The Egyptians laminated thin strips of the stalk of the papyrus plant and produced a writing surface. The Chinese made the first true paper by macerating cotton or linen cloth into pulp and recovering the fibers as a thin sheet.

"For centuries, cotton and linen rags were the raw material for the papermaker. But with the invention of printing, demand for paper became so great that by the middle of the 18th century, there were not enough rags available. The French scientist Réaumur suggested in 1719 that paper might be made from wood as he had observed that wasps in making their nests produced from wood a material closely resembling paper. Réaumur did not pursue this line of investigation although in the following years many similarly inquisitive and practical men made the same observation and began to make paper experimentally from various cellulosic natural products.

"It is only natural that what we know as mechanical pulp or groundwood should be the first papermaking fiber produced as this followed the reasoning of the ancient Chinese and Egyptians. There is a record of a book printed in 1800 on straw paper that was produced by some method of grinding. But it was not until 1852–54 that the first European patents were granted on a successful commercial application of a groundwood pulp produced as we know it today. It was not until 1867 that the first groundwood mill was started in the U.S.A. Please do not hold me to the accuracy of these dates as I find references varying over several years.

"Groundwood fiber at first was used as an adulterant and extender for rags, and it was soon realized that mechanical treatment alone did not give a papermaking fiber that could be used alone or even as an extender with rags for the finer grades of paper.

"Scientists considering the success of mechanical treatment wondered why the bonds of pitches and resins cementing the fibers together could not be broken by other than mechanical means and turned their investigation to some method of effecting the separation by chemicals. The first success in this direction was by the soda process, patented in Europe in 1853, in the U.S.A. in 1855. This was followed by the sulphite process by an American in England, Tilghman, in 1866, whose process was not too successful, and later in 1874 by Ekman, a Swede, whose patents were brought to the U.S.A. in 1878.

"The third major chemical process, sulphate, was first patented in Danzig in 1884 and the first North American plant was built at East Angus, Quebec, in 1907. The Brown Corp. at La Tuque built the second one in 1910. Since 1920, semi-chemical pulping, a combination of the mechanical and chemical processes, has been becoming increasingly important as it utilizes woods of species and sizes not economical for the other methods of manufacture.

"Starting with the early 1930's, a most significant change has taken place in the ability of the industry to utilize new wood species. For years it was thought that only the soda process could use the deciduous or hardwood species, northern spruce or fir being necessary in all others. The depletion of our northern forests forced the development of the technique of using not only northern hardwoods by the sulphite and sulphate processes but also western hemlock, southern pine, and southern hardwoods, and the increasing demand for cellulose may widen this field. I may mention that other plant life is used such as straw, bagasse, esparto, and, of course, hemp and jute, but these are only minor sources of raw materials.

"I believe this gives you a picture of the past and present of the cellulose industry and I will now give you a short description of what happens after the wood reaches the mill. I will refer to the sulphite process only.

"After suitable aging in outdoor storage, the pulpwood is barked either in steel barking drums where the bark is removed by pounding or rubbing or by the hydraulic process. That portion of the wood which passes inspection for cleanliness and freedom from defects is reduced to chips averaging some $^{5}/_{8}$ inches square and $^{1}/_{16}$-inch in thickness. The chips are then placed in temporary storage where they await con-

One of two Lobdell Stacks to be used on a vat-type Downingtown Board Mill of 122" capacity. The machine is designed to produce calendered paperboard of various types calipering from .016 to .070 with a #3 smooth, water finish. The stacks are water-cooled with closed-end bronze bearings and ratchet lift . . . the wet end stack has seven rolls and the dry end stack is equipped with nine rolls. Write for detailed information about these and other Lobdell Machine Calender Stacks.

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veyance to large steel cylinders called digesters where they are cooked in an acid calcium bisulphite liquor under controlled conditions maintained through the use of instruments. This cooking represents a hydrolysis of the fiber, removing lignin and part of the lower carbohydrates from the wood. The cook is discharged into a blow pit and later screened and repeatedly washed for removal of materials which have resisted the cooking process.

"For attainment of high color, stability, and a high degree of cleanliness, the pulp is then subjected to a bleaching procedure in tile lined tanks by the application of bleaching agents. The bleaching process, as well as other chemical treatments of the pulp looking toward its purification, may be regarded as processes of secondary digestion. Special treatments used to produce grades of highly purified wood cellulose, of improved color and high alpha cellulose content, include the use of cold or hot dilute alkali or cold concentrated alkali. These secondary purification treatments are of the widest variety since it is necessary to produce different grades of pulp for a multitude of end uses. In general, wood pulp may be divided into grades for papermaking where the physical characteristics of the fiber are of primary importance and the pulps for chemical conversion where the chemical characteristics become paramount. Some chemical pulps, for example, must be controlled with regard to viscosity, filterability, and heavy metal content.

"After bleaching. the pulp undergoes a final drying process on a machine similar in construction and operation to the equipment used in making paper. It may come off the machine in rolls or in sheets which are baled and stored for shipment. If the pulp is destined for papermaking purposes, special controls in its finishing are usually unnecessary. If it is to be used in the dissolving field, special attention is given to control of sheet size, moisture content, basis weight, and thickness.

"In the paper mill, the pulp fibers are again dispersed in water in a beater and the desired amount of hydration is obtained from mechanical action in such equipment. This may or may not be supplemented by other types of equipment such as jordans. Any number of different chemical agents can be added to the fiber in the beater in order to modify the characteristics of the paper being manufactured. The treated cellulose is run onto the paper machine at very low solids concentration in order to obtain good sheet formation. At the wet end of the paper machine there is usually no more than 0.5% of fiber in the water. After the sheet is formed it is passed through a series of rolls for drying and will come off the dry end of the paper machine with only 5% of water present. Various finishing operations can then be employed in the paper mill depending on the end product being manufactured. On the other hand, much paper is simply made into rolls and stored for later shipment to paper converters."

Brown Company Products

"Brown Co. makes both sulphite and sulphate process wood pulp. Of the chemical pulps, Brown Co.'s Dur Sylvan is a hardwood base fiber possessing chemical and physical characteristics which makes it adaptable to the rayon process. Our Dur Natus is also a hardwood base fiber of general use in the dissolving field and of particular merit in the manufacture of cellophane. In the conversion of this pulp to cellophane allowance must be made for conversion of the wood pulp to alkali cellulose in the steeping press, shredding the steeped sheets, aging of the alkali cellulose, conversion to cellulose xanthate in barrattes with carbon bisulphide, mixing and conversion to viscose, followed by a ripening period. The ripened viscose is extruded through an orifice into a fixing bath where the film is formed.

"While Brown Co. makes only certain definite types of papers, we do supply wood pulp suitable for virtually all types of papermaking and have pioneered many improvements in the papermaking art which are conducted by our customers through the use of our pulps. For example, our special Dur-Alba hardwood pulp is widely used in conjunction with softwood fibers in order to obtain better formation in the finished sheet of paper. The way this can operate can be seen from the high degree of uniformity of the dispersion of hardwood in water."

Cellate

"Our Cellate is the first fully bleached sulphate pulp to be made on the North American continent. In it is offered to the papermaker a material which is capable of providing all of the strength characteristics inherent in kraft paper with the whiteness and color range previously available only through the sulphite process. Brown Co. has also carried this development forward and is supplying a similar grade of pulp derived totally from hardwood. This is our Durakraft. It is only in the last 25 years, or so, that wood pulp has really come into its own in the manufacture of permanent papers. Up until that time, it was the belief of papermakers, printers, and publishers that the relative permanence of paper was closely allied with the rag-fiber content of the papers in question. There was evidence that 100% rag papers made over 50–100 years earlier had withstood the ravages of time, but that papers which were produced from other than cotton or linen fibers, i.e., sulphite pulps, groundwood, etc., deteriorated in less than 50 years.

"Brown Co. research has definitely proved in theory and practice that in the absence of other substances which tend to decompose cellulose, such as acid, rosin, iron, etc., a fiber, high in alpha cellulose content such as our Solka-pulps, will withstand the effect of weathering agents as successfully as cotton or linen fibers.

"Purified wood cellulose lends itself to the manufacture of the highest type of paper without the necessity of the customary prepreparation of the rag stock. It is fed to the hydrating equipment as any conventional pulp (the beating cycle is more like rag than most wood pulps), and after the prescribed hydration based on the type of paper sought, the paper web is formed on the paper machine, sized or unsized as desired, dried, and put into finished sheets or rolls.

"Brown Co. accelerated aging tests of paper made from high alpha wood cellulose have proved conclusively that papers can be produced having all the strength qualities and permanence of the best cotton or linen sheets."

Solka-Floc

"Further pioneering by Brown Co. has led to a finely divided wood cellulose, Solka-Floc, which is of the highest interest because of the variety of its applications. First developed for plastics molding powders and filtration, its latest accomplishments are in the production of suède finishes, such as required for velour paper, and in the field of chromatography. In the latter instance, Solka-Floc BW-200 is used to adsorb active biologicals, such as ACTH, from dilute solution and assist in their isolation and purification. A large-scale usage of Solka-Floc is in rubber compounding, particularly in products such as shoe soles and floor tile. Solka-Floc is also an essential ingredient in cellulose-coated welding rods which are a boon to multipurpose, all-position welding. But the use of Solka-Floc which will probably be of greatest interest to you is in the chemical field. It has afforded a brand-new approach to the handling of cellulose for chemical conversion to a variety of products, particularly the water-soluble cellulose gums.

"Since Solka-Floc is finely divided, it exhibits uniquely high reaction rates in comparison to other forms of cellulose, and its use as starting material permits great simplification in equipment and operations and reduction in processing time in comparison to the classical approach to cellulose derivatives. An example of the ultimate in this simplification is the conversion of Solka-Floc in a single operation with theoretical amounts of reagents and in a single piece of equipment such as

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a tumbling barrel, or dough mixer, into a technical grade of CMC ready for incorporation in detergents and with a total reaction time of some 4 hours.

"Similar results with Solka-Floc are being obtained commercially in making other derivatives and the final range of this new approach through finely divided cellulose is yet to be determined. It is already clear that alkali cellulose derived from Solka-Floc BW-100, for example, is 80% denser than that from sheet pulp, thus resulting in additional processing economy since more product can be obtained from given equipment and labor."

Chicago

The Chicago Section met at the Chicago Bar Association quarters on May 21. F. D. Long of the Container Corp. of America, Chicago, Ill., presided as moderator at a panel meeting on "Corrugated Containers." Members of the panel included C. R. Vander Meulen, Penick & Ford, Ltd., Cedar Rapids, Iowa; E. M. Hertzmark, Silicate Division, Diamond Alkali Co., Cleveland, Ohio; and Charles Miehle, Production Superintendent, Eddy Paper Co., Three Rivers, Mich.

The talks given by Messrs. Vander Meulen and Hertzmark follow.

The Use of Starch Adhesives on the Single Facer in the Manufacture of Corrugated Board

C. R. Vander Meulen

Any discussion of the manufacture of corrugated board is bound to contain a repetition of familiar material but new ideas and processes are continually being evolved. It is through group meetings such as this with its interchange of ideas that progress can be made and perhaps some degree of standardization may gradually be accomplished. Any discussion of adhesives as used on the corrugator will include other variables such as machine condition, heat available, condition of paper, various additives, operator preferences, etc., but usually if difficulty occurs, the adhesive will be the first thing to be blamed. In fact, one superintendent remarked to me, "Even if my roof leaked, I'd blame it on the starch!"

The basic starch formula has approximately 20% commercial solids and contains the common additives, caustic soda and borax. The preparation of the adhesive consists of heating an aqueous suspension of starch in the presence of caustic for the carrier portion and later adding additional water, borax, and the raw starch portion. The function of the carrier portion is to keep the starch in suspension and to assure the presence of sufficient water in the glue line to permit complete pasting or gelatinization of the raw starch portion after the adhesive has been applied to the board. It is, therefore, principally the raw starch portion that forms the bond when it is cooked on the machine.

It was common practice formerly to use a two-piece formulation, i.e., to use a thinner boiling starch for preparing the carrier and an unmodified starch for the raw portion. The more recent trend has been toward a one-piece formula using the same type of starch in the carrier as is used in the raw starch portion. A smaller amount of this thick boiling starch is therefore used in the preparation of the carrier portion to produce a suitable operating viscosity; hence a lower percentage of starch used in the carrier assures a larger portion of the raw starch, which is the real adhesive. Recently, it has been observed that a more stable viscosity can be obtained if the carrier starch portion can be hydrated in the presence of as much water as possible. Also, it is believed that better stability is obtained if the full borax effect on the carrier portion can be realized by addition before the raw starch portion is mixed in.

C. R. Vander Meulen, Penick & Ford, Ltd., Cedar Rapids, Iowa.

CAUSTIC AND BORAX

The additives, caustic soda and borax, are specifics in the corrugating starch formula. The caustic soda controls the temperature at which the starch gelatinizes. Regular corrugating starch made from corn begins to swell at about 160 to 165°F. and requires cooking to 180 to 190°F. for complete gelatinization. Caustic soda will lower the gelatinization temperature. The use of $2^1/_2$ to 3% caustic on the dry weight of the starch will lower the gelatinization temperature to the proper range to assure faster cooking of the starch and thus allow for higher speeds on the machine. For most efficient operation of the single facer, therefore, the gelatinization temperature should be as low as possible without causing difficulty with the adhesive gelling in the pan or on the fingers. Higher steam pressures and the compact construction of some corrugators, which restricts air circulation, require one to operate with less caustic or a higher gelatinization temperature. Blower fans or compressed air may be used to move air over the glue pan. Some recently observed homemade equipment using compressed air was in principle similar to a Penberthy steam injector, and it seemed quite efficient. Good circulation of the starch in the pan is important and the most effective system has the inlet in the center of the pan with a tee allowing for flow in two directions and overflows at either end of the pan. The splash guard could be constructed so that cold water can flow through it and thus cool any starch which is deflected by it to the pan. Some operators have moved the splash guard entirely, allowing for better air circulation even though this permits a very small amount of starch to be thrown onto the floor or into the drainage area around the single facer.

Borax is used to the extent of about 2.75% of the dry weight of the starch. Its purpose is to increase the viscosity and tack of the raw starch portion after it has been pasted. Under certain conditions, especially on the single facer, it may be of assistance to lower the borax content or eliminate it entirely. Difficulty was encountered with a special corrugating medium at one plant. The medium was not excessively sized but sufficient penetration was not being realized. At the single facer, the adhesive is heated almost instantaneously and then cools rapidly as the sheet proceeds over the bridge. The starch therefore sets quickly but reduction or elimination of the borax allows the adhesive to remain in a more fluid state for a longer time and this allows for better penetration. The use of too high a percentage of borax may produce a bond which is too brittle.

VISCOSITY

Any discussion of viscosity is likely to be controversial. I know of two plants in the same organization where one insisted on maintaining a viscosity of above 35 to 40 seconds and the other insisted they could not operate successfully unless the viscosity was 25 to 30 seconds. We feel viscosity should be sufficiently high to prevent settling of the raw starch portion, to assure retention of the water in the glue line for proper hydration of the starch when cooking, and in a range which provides for satisfactory pickup and transfer on the machine. The viscosity should be maintained at a constant level so that a uniform pickup is realized to assure a consistent operating condition. Too high a viscosity results in excessive ringing or throwing of the adhesive into the flutes and perhaps excessive pickup. This may be responsible for washboarding and warping especially with low basis weight liners. In an increasing number of plants, improved results on the single facer are being obtained with viscosities between 25 and 30 seconds in accordance with machine conditions and adjustments which will be discussed later.

Considerable thought and effort has been given to the stabilization of viscosity during the past several years. Some success has been achieved but careful analysis and testing of various special carrier starches indicate relatively little im-

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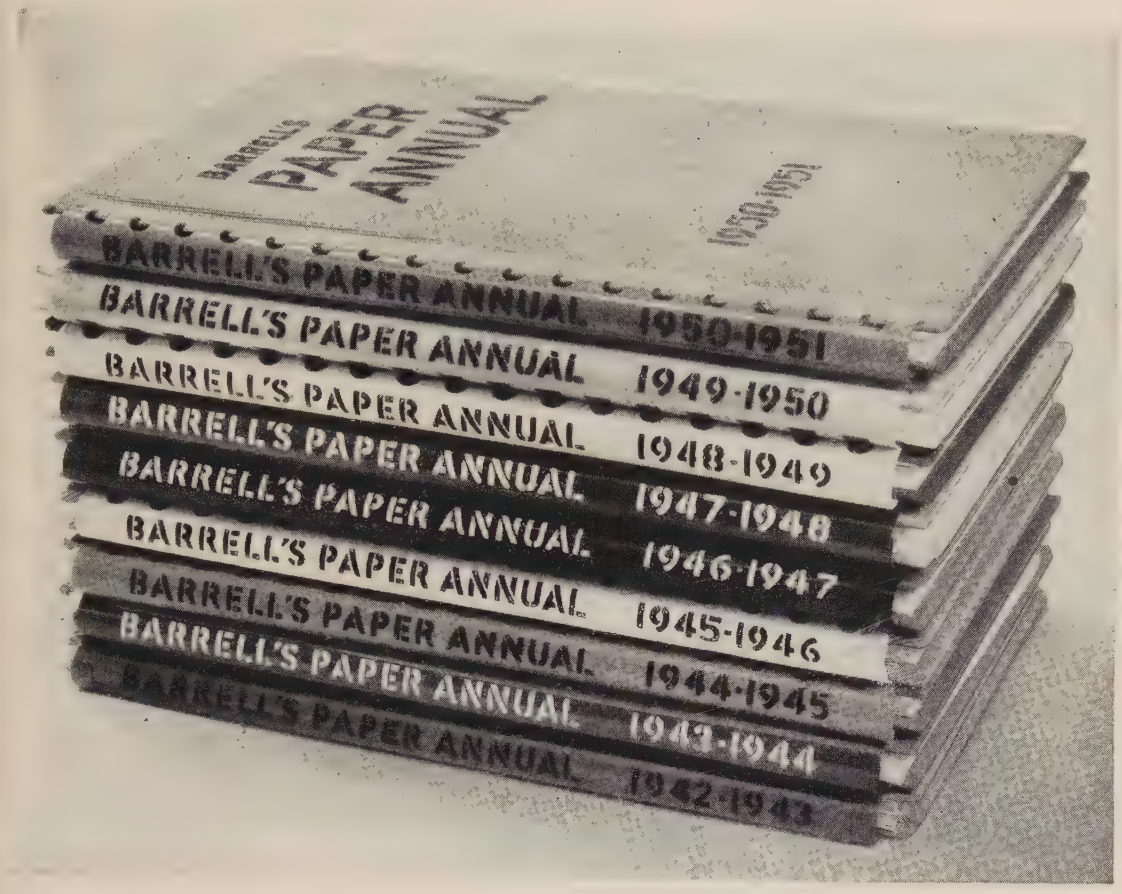
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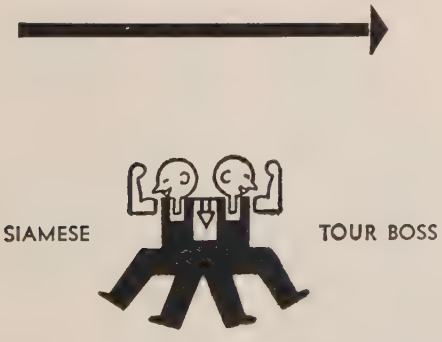

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provement with reference to increased viscosity stability. Stabilization of viscosity can be successfully accomplished by reacting the carrier starch with an alkaline setting ketonic resin. The process is comparatively simple, the cost negligible, and, if serious difficulty with breakdown is a problem, this process would be a solution.

The use of alginates with corrugating starch has been a development of the last few years. The alginate seems to have a stabilizing effect on viscosity. In addition, its ability to hold water may make it effective in keeping the water in the glue line, thus allowing for proper cooking of the starch. Its property of holding water may permit better distribution and control of the glue line. Thinner viscosities may be employed, thus permitting thinner and smoother films on the glue rolls. The use of products like CMC, locust bean gum, and the Penford gums which are hydroxy starch ether derivatives of cornstarch all give similar properties to corrugating starch.

SPREADS

A good average spread for corrugating starch would be in the range of 2.5 to 3 pounds per thousand square feet of two-faced board. This would be split about equally between the single facer and the double backer although one would expect less consumption on the single facer since the clearances at this station are usually smaller. Considerable emphasis is placed on the saving of starch by keeping a close check on the spreads. This practice of keeping spreads at a minimum is good not only for economy but also for improvement of board quality by elimination of excess moisture. The starch adhesive represents such a small portion of the cost of a corrugated box, however, that it does seem unwise to reduce the adhesive cost to an absolute minimum. It seems far wiser to keep a fair factor of safety to take care of variations in paper surface, moisture, sizing, etc. At 3 pounds of solids per thousand square feet of board, the cost would be approximately $0.18 for a box having 10 square feet of board. The cost of fabricating such a box would vary, perhaps, from plant to plant, but according to the selling price of a certain box of approximately 10 square feet, the cost of the adhesive would amount to less than 1%. A reduction of spread by $^1/_2$ pound per thousand would amount to a saving of less than 0.15% of the selling price. Reducing spreads to the absolute minimum, therefore, should be watched especially if additional scrap is produced while attempting to make the saving.

STARCH FOR WATERPROOF BOARD

In the use of waterproof starches, most of the difficulty in obtaining a good bond seems to be on the single facer. The earliest formulas were those in which the urea formaldehyde resin and catalyst were added after preparing the starch and careful control of temperature and pH was necessary for good pot life. The reacted starch process (United States pat. No. 2,450,377) was then developed, and this requires less technical control because the procedure produces an adhesive in which the pH does not change and any storage or circulating temperature below the actual gelatinization temperature of starch may be employed. The process involves the cooking of urea formaldehyde resin or dimethylol urea with the carrier portion and reacting the mixture at 190 to 195°F. by reducing the pH through addition of alum or some other catalyst. A fluid, long-bodied adhesive results which is mixed with the raw starch portion. This process or others similar to it are in general use today. Since no caustic soda or borax can be used in this acid-setting type of formula, a gelatinization temperature of at least 185°F. must be reached in the glue line and slower speeds result. Other formulas involving the use of alkaline setting ketonic and resorcinol resins have been evolved together with formula containing polyvinyl alcohol. These looked promising at first but results on the single facer especially with the more highly sized liners indicated that the specifications for the 24-hour soak test could not be consistently met. Work on these formulas is continuing in the hope of developing adhesives which will permit higher operating speeds. Theories as to why failure occurs on the single faced side include the application of more pressure which forces glue to each side of the tip of the corrugation together with different curing conditions such as less time under heat and in the presence of high humidities.

In general, the clearances on the single facer for water-resistant adhesives must be much wider, i.e., 0.012 to 0.018 inch, for a good waterproof bond which will withstand the soak test.

There is such a close interrelation between the variables encountered in producing corrugated board that classification of the difficulties or defects according to cause might find the same defect listed under several headings. In compiling a list of defects, I have grouped them under the headings of adhesive, paper, and mechanical. The corrugated box manufacturers and allied industries deserve to be complimented for the high standards achieved, but constant watchfulness and effort are required to maintain these standards. In listing the defects and their causes, the correction is obvious in most cases and little comment is required.

Under the difficulties encountered with *adhesives*, I have listed "snappers" or "dry-peeling," finger lines and spotty or streaky glue pattern. There may be several reasons for "snappers" or "dry-peeling." Among them are:

A. Insufficient adhesive.—This would be caused by having the clearance too low so that not enough adhesive is applied or improper fluff-out of the medium so that not enough adhesive is transferred.

B. Too much heat.—If the adhesive is dried too much, it will become brittle. This does not occur too often on the single facer but is more likely to occur on the double backer if the board is allowed to bake between the belt and the hot plates when the machine is stopped.

C. Not enough heat.—If the starch is not cooked out properly, a good bond will not be formed. Improper cooking will be shown by a grayish or whitish cast in the glue line. The temperature of the rolls should be checked together with steam pressure, siphons, etc. The machine should be slowed down if no immediate correction can be made.

D. Hot paper.—This does not occur frequently but is likely in a mill where the paper is brought directly to the box plant from the mill. Hot paper results in too much penetration of the adhesive or too much heat. Bypassing of the preheaters is a corrective measure.

E. Too much borax.—This is not frequent. The obvious correction is to lower the borax content by 50% or eliminate entirely.

F. Gelatinization temperature too high.—If the gelatinization temperature is too high, the starch will not cook properly. An immediate corrective measure is to reduce the machine speed until a fresh batch can be made with an additional amount of caustic.

G. Corrugating starch too fluid.—If the starch is too fluid, the water may penetrate into the paper so that the starch will not hydrate completely. Or the adhesive may flow away from the tip of the corrugation leaving insufficient adhesive for a good bond. Higher viscosity, or, perhaps, specific water holding additives discussed previously are obvious solutions.

H. Solids too low in adhesive.—Low solids formulas are generally not recommended for all-round use. A low solids formula can easily be made by increasing the amount of starch in the carrier portion and adding additional water to obtain a suitable working viscosity. It is felt that low solids formulas do not allow for a good factor of safety and that any economy may soon be offset by waste. Low solids may be caused by leaking of water into the tanks or by flushing of water into the starch during clean-ups.

I. Spoilage of starch through bacterial action.—If the starch is held over too long without a preservative, it may be liquefied by bacterial action so that poor bonding will occur. Good housekeeping and the use of preservatives are recommended.

Finger lines are a common defect, and the reason for them is that the adhesive is not applied or does not flow onto the tip of the corrugation at the point of contact of the finger and the paper. They should be kept as narrow as possible and a more fluid adhesive allowing for better flow conditions is

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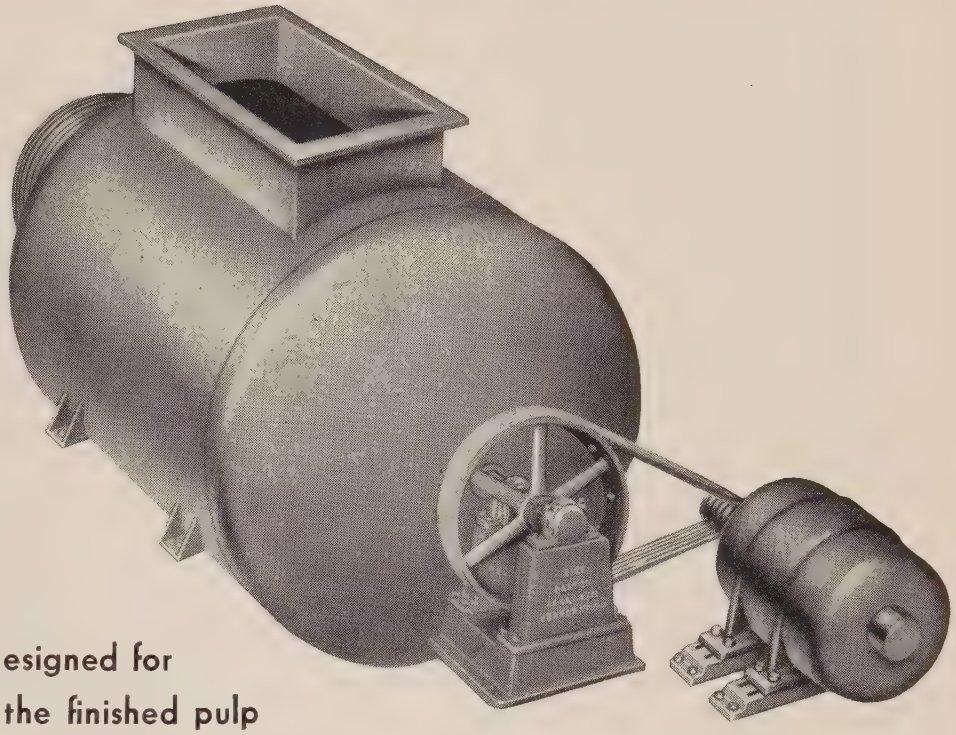
...ideal for disintegrating pulp, broke or waste papers



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The DynoPeller

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more favorable than a heavy, cohesive corrugating starch. A new idea for the elimination of finger lines, which may be familiar to you and which I believe was originated by the Langston Co., is the cutting of a small notch in the arc of the finger at the point of glue application. This allows for flow of the adhesive along the tip of the corrugations, thus tending to eliminate the finger lines. If the gelatinization temperature of the starch is too low, a build-up of gelled starch may occur on the fingers which will cause a wiping action and a widening of the already occurring finger lines.

Spotty and streaky glue patterns are another frequently occurring difficulty on the single facer. This difficulty may be caused by:

A. Dirty transfer roll.—Good housekeeping is involved and the rolls must be kept clean and in good condition. The gelatinization temperature of the starch again may be too low, causing a pick-up of cooked starch on the roll.
B. Dirt, scraps of paper, gelled starch, or other debris may be caught in the nip between the transfer roll and the pick-up or doctor roll. This will cause a wiping action leaving a bare spot on the transfer roll, with resultant streak on the paper which is bare of adhesive.
C. Ringing of the adhesive.—If the adhesive is too heavy and cohesive, an excessive ringing condition of the adhesive will occur. This will cause a heavy application of adhesive at one spot with a light application or none at all at another. A more fluid adhesive is suggested. Also, the use of small sections of threaded rod may be used to minimize the ringing condition. These rods may be $^3/_4$ inch in diameter, have about 16 threads per inch, and should be cut in about 8-inch lengths. These small sections of rod would be placed in the nip of adhesive rolls and should be removed and placed in a can of water for cleaning when the machine is stopped. The reversal of rotation of the doctor roll so that it revolves in the same direction as the transfer roll also is effective in smoothing out the film. A wiper blade on the doctor roll is needed in this case.
D. Improper fluffing out of the paper resulting in poor adhesive pick-up.—The condition and type of paper enter into this, along with heat available on machine and the setting and arc of the fingers.

When considering the *paper* used, it may have an effect on poor bonding and on defective corrugations. Poor bonding may be caused by:

A. The paper being too hot and dry.—This has already been mentioned as having an effect under adhesives.
B. The paper being too porous.—This results in too much penetration. The use of film formers or hydrophilic additions or possibly some other ingredient to prevent penetration is a remedial measure.
C. Dense paper.—If the paper is too dense, the adhesive may not bite into the fibers satisfactorily. The use of steam showers to open up the sheet is advised. More caustic may be used provided the gelatinization temperature is watched carefully.
D. Sizing.—If the paper is too highly sized, again the adhesive will not bond properly. This may be especially true when running waterproof board and too much of the agents providing wet strength is incorporated into the board. This may be checked by use of the immersion number test. The machine may be run at slower speeds to obtain proper bonding.
E. Too much moisture in paper.—Too much moisture in the paper will cause poor bonding and especially results in loose edges. The paper should be given as much preheater wrap as possible and the machine run slower to improve running conditions.

The condition of the paper may cause defective corrugations or defective board. Too much moisture may result in knocked down corrugations, soft board, or warp of the sheet. Variations in caliper may cause knocked down corrugations, or fluttering with loose edges. A roll of this kind will run better on the double backer. The condition may be corrected by steaming of the tight edge or adjustment of the roll stand. Improper fluffing out may result in hi-low flutes or poor bonding. This will be discussed more fully later.

Under machine or mechanical considerations, difficulties may be listed as occurring at the corrugating rolls, the fingers or crescents, the pressure roll, the tension on the paper, the heat available on the machine, and the glue mechanism.

At the *corrugating rolls*, several conditions may cause difficulties:

A. Temperature.—The temperature of the rolls should be kept at a maximum and approximately equal across the width. Lack of sufficient heat will cause irregular fluffing out, blisters, etc.
B. Cleanliness.—Dirty corrugating rolls will cause crushing of the flutes or tearing of the flutes in a machine direction. Adhesive build-up along the edges of the paper will cause loose edges. Dirt on the rolls will prevent proper fluffing out of the medium. The rolls should be kept clean by a daily treatment with oil and steam. The slots must also be cleaned to prevent wearing on the fingers.
C. Condition.—Worn corrugating rolls will cause hi-low flutes or board not up to caliper. The machine should not be run without paper in the rolls since this causes excessive wearing. Where narrow paper must be run, it should not all be run in the center of the machine but should be moved to different lateral positions on the machine. The rolls should be kept in good condition by honing and polishing with an oil and graphite mixture.
D. Position.—If the rolls are run out of parallel, hi-low flutes or pulled corrugations will result. The lateral position of the rolls should be changed periodically to prevent uneven wearing. The bearing blocks must be checked frequently since worn blocks cause difficulty with improper meshing of the rolls which results in knocked down corrugations and hi-low flutes.
E. Pressure between corrugating rolls.—If the rolls are set too deep, cut corrugations will result. If too loose, hi-low flutes are formed. The pressure between rolls must be checked carefully and the operators instructed to gage the pressure properly.

The settings and condition of the *fingers* has an important effect on difficulties at the single facer.

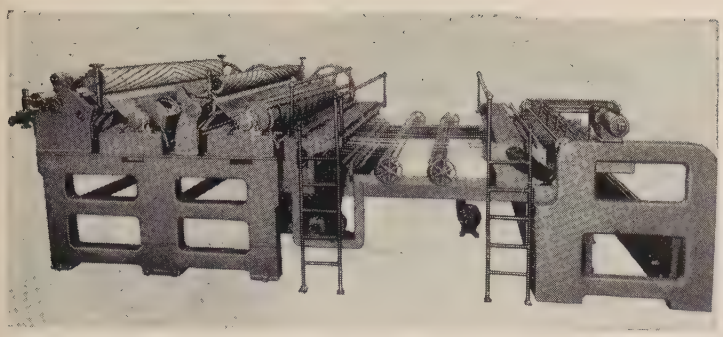
A. The fingers must be kept clean since dirt or an accumulation of gelled starch will cause blisters, dry streaks, or wide finger lines.
B. The proper arc is necessary for the fingers. Worn or bent fingers result in poor fluff-out with resultant hi-low flutes, crushed or pulled corrugations, and blisters.
C. All fingers or paper guides must be set properly and the setting must be the same. A convenient method of setting is to insert a piece of 9-point and then back the fingers away 3 points. The position of the paper with regard to fingers is important. It must not overlap the outside fingers too far or loose edges will result. Insufficient clearance will result in more prominent finger lines and loose fingers cause knocked down corrugations and spotty application of adhesive.
D. A notch in the arc of the finger at the point of glue application has already been mentioned as a means for elimination of finger lines.

At the *pressure roll*, several conditions may exist which will cause various defects:

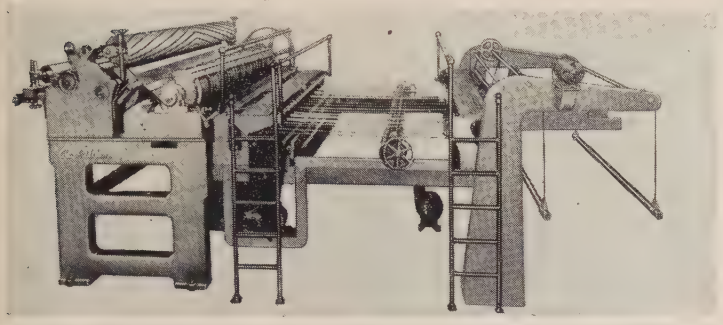
A. An uneven pressure or improper crown on this roll will cause cut corrugations, loose edges, or blisters.
B. The rotation of this roll must be synchronized with the corrugating rolls. Off-timing will result in pulling of corrugations. It is better to have the pressure roll driven by the drag of the paper than to have it driven out of time with the corrugating rolls.
C. Adhesive build-up or dirty pressure rolls will cause knocked down corrugations.

The *tension* on the paper at the roll stand, if it is too great, will cause corrugations, leaning, or a long narrow blister. Also, blisters ensue if not enough tension is put on the paper. Warping in the length of the sheet follows if there is an uneven tension on the single faced sheet into the double backer.

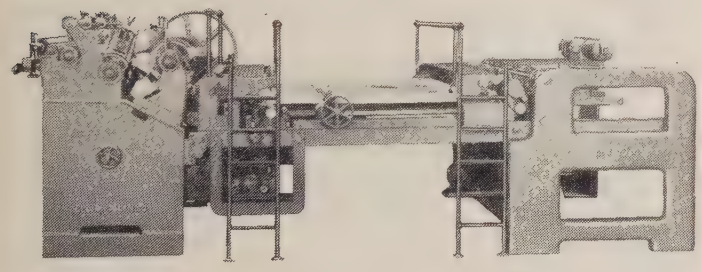
The *heat condition* prevailing on the machine is one of the most important considerations. Insufficient heat will cause irregular fluffing out, improper cooking of the adhesive, loose edges, warp in the width of the sheet, and uneven or poor corrugation. A minimum steam pressure of 125 pounds is recommended and for high speeds, a pressure of 175 pounds is



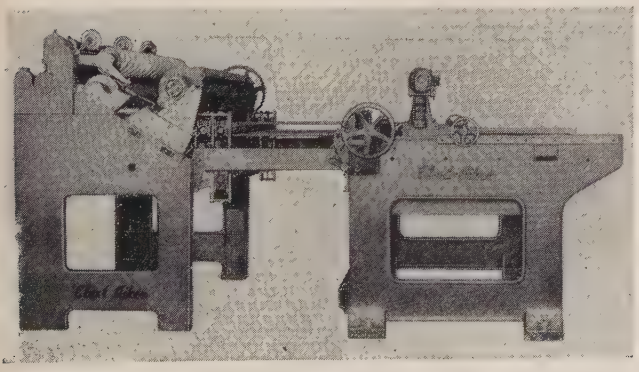
Clark-Aiken Type H High-Speed Heavy-Duty Duplex Cutter-Layboy Unit for high-speed cutting of board, or pulp and multiple sheeting. 76" to 220", inclusive, with or without overlapping delivery Furnished with conventional layboy as illustrated or overhanging type layboy shown below.



Clark-Aiken Type H High-Speed Heavy-Duty Simplex Cutter-Layboy Unit for heavy service. 76" to 220" inclusive. Conventional or overhanging type layboy (illustrated) for side removal of piles



Clark-Aiken Type C Super-Speed Precision Cutter-Layboy Unit for extreme accuracy in sheeting rolls 76" to 124", inclusive. Conventional or overhanging type layboy, with or without overlapping delivery.



Clark-Aiken Type D High-Speed Economy Cutter for finishing room service and for use of converters and printers. 36" to 100", inclusive, with or without overlapping delivery. Conventional or overhanging type layboy.

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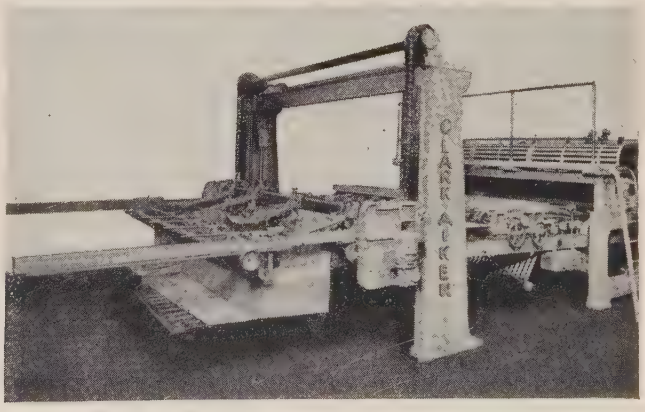

Clark-Aiken "Vickery" Layboy. Skids rest on floor and delivery rises as pile height increases. Piles may be removed from side or rear and delivery quickly drops to starting position greatly reducing cutter down-time. Available for all Clark-Aiken Cutters.

better. The temperatures of the corrugating rolls should be maintained in the range of 320°F., and 330 to 340°F. is preferred. Steam pressure alone will not maintain the high-temperatures desired. It is important that a high rate of circulation is maintained and that the drainage system, i.e. steam traps and siphon pipes, be kept in good working condition.

Conditions existing at the *glue mechanism* are important. Good circulation in the pans is necessary to prevent gelling. Clearances between transfer roll and pick-up roll must be adjusted for best economy and good board. If the clearance is too low, a poor bond may result. If too wide a clearance is used, a soft sheet caused by too much moisture may result together with poor economy. It was formerly recommended that the clearance between the transfer roll and corrugating roll be about 0.026 to 0.030 inch. More recently, it is being recommended that this clearance be kept at an absolute minimum. On some new machines, these clearances are in the range of 0.012 to 0.014 inch. On these machines, the applicator-pickup roll and doctor roll rotate in the same direction with a doctor blade wiping excess glue off the doctor roll. Since the corrugating medium is about 0.009 inch, little fluff-out is required to get transfer of adhesive. On older machines where exceptional care is taken in the operation, clearances of about 0.015 inch are being used with very good results in the quality of the board.

This new conception of running with closer clearances between the transfer roll and the large corrugating roll is based on the fact of the less fluff-out, the better. It is felt that fluff-out, especially if it is appreciable, brings about some of the distortion of the flutes with resultant hi-lows and with some of the modern corrugating media, this fluff-out does not occur too readily. Hence, with a larger clearance, in addition to distortion, there will be bare spots where adhesive is not picked up.

To run with closer clearance, other factors must be taken into consideration. One of these is the glue film and it must be uniform with a minimum of beading or ringing. To obtain this effect, thinner viscosities are being used and the rotation of doctor roll in the same direction as the fountain-transfer roll is also effective in obtaining the uniform film. On the older type of machine, adjustable scrapers on the ends of the adhesive applicator roll are beneficial in keeping the roll clean beyond the edges of the paper so there is little chance of the adhesive beads being transferred to the corrugating rolls. Even without the scrapers, some of the machines are being run with clearances below that formerly recommended, but the viscosity and other characteristics of the adhesive must be considered together with proper condition of the adhesive rolls. Where the clearances have been held to an absolute minimum and the machine run with careful attention to all details, the quality of the board has been found to be much improved especially in regard to hi-low flutes. Additionally, it has been found that the fingers last much longer, sometimes being changed only twice a year.

Discussion of any formulas in detail has not been included in this paper since they are all very nearly standard and will be recommended by your supplier.

Q. Does the starch in the carrier portion have any effect on the bond?

A. Any cooked starch has a certain amount of adhesive power. So the carrier portion probably has some effect on the bond but in just what proportion it is difficult to say. It is felt that in corrugating starch the raw starch portion does most of the actual bonding.

Q. What is the proper gelatinization temperature to use on the single facer?

A. As low as possible depending on conditions at the single facer and so that a minimum of gelling on the fingers, etc. and in the pan will occur. Gelatinization temperatures are being used from 140 to 142° to over 150°F.

Q. Is there any advantage to using different formulas on the single facer and double backer?

A. I have mentioned the use of thinner viscosities on the single facer in conjunction with closer clearances between transfer roll and large corrugating roll. On the double backer, the preference has been to maintain a heavier viscosity. Also, there seems to be a great advantage to a formula containing more caustic soda for the double backer where less heat prevails so that higher speeds can be maintained. This is especially of benefit when running double wall.

Q. Are there any other materials which can be used with corrugating starch?

A. Yes, diatomaceous earth, clay, sulphonated oil, Kelsize, and silicate. Diatomaceous earth and clay have been used in high percentages in attempts to obtain stiffer board and reduce costs. Sulphonated oil has been used for the wetting effect to obtain better penetration and to get a better spread on the tips of the flutes. Kelsize, a more recent recommended additive, has already been discussed. There are some current reports of starch and silicate being used together with very good results. It has been reported that the combination sets up faster than regular silicate and produces board with higher compression and flat crush. Starch, silicate, and diatomaceous earth combinations have been observed to be very effective and one point noted was that the adhesive did not adhere to hot metal.

Q. What is the status of the alkaline weatherproof process for corrugating starch?

A. To the best of my knowledge, no one has solved this difficulty on single facer with pressure type corrugators.

Operation of the Single Facer with Sodium Silicate

E. M. Hertzmark

Any process material requires correct usage and proper operating practice in order to derive the maximum benefit. I propose to discuss the application of the above with regard to the use of sodium silicate on pressure-type single facers as they predominate in the corrugated industry today.

Research experiments have shown that the adhesive applied in the manufacture of corrugated board must be regarded as one of the structural members of the box and not just a means of adhering the liners to the corrugating medium. Silicates, when properly applied, contribute to the structural strength of the box, due to the rigid shoulders formed on either side of the glue line. Proper application of silicate requires accurate settings on the single facer and proper conditioning of the liners and corrugating medium before and after the components are joined. Certain housekeeping procedures are also necessary in order to obtain the beneficial results with silicate.

As supplied by the manufacturer, sodium silicates are of a certain ratio and viscosity, such that with the proper control within the plant, they will perform most satisfactorily under a wide range of temperatures, speeds, types of paperboards, and mechanical conditions, thus permitting an extraordinary flexibility in the combining operation. While the user has no control over the ratio, his operating practice can affect the viscosity. Straight silicates are standardized at 68°F. Increasing the temperature decreases the viscosity such that the formation of good shoulders and proper penetration are hampered. Overheating of the silicate results in differential penetration and bond formation across the glue line and may also cause setting of the silicate on the glue rolls while the machine is idle and the formation of a skim over the top of the silicate. The use of a center feed, with overflows at either end of the pan, and the installation of a baffle over the glue pan to prevent the steam from the showers from contacting the silicate surface, is recommended for maintaining the proper silicate temperature.

Due to variances in types and condition of repair of machines, steam pressure and auxiliary equipment available, and the types of liners and corrugating medium that are in use in the industry, it is possible to only give ranges of clearances between the glue rolls and between the transfer and lower corrugating rolls. For the former, the range is 0.006 to 0.011 inch, and for the latter, 0.028 to 0.035 inch. The conditions,

E. M. Hertzmark, Silicate Division, Diamond Alkali Co., Cleveland, Ohio.

for low cost, experimental

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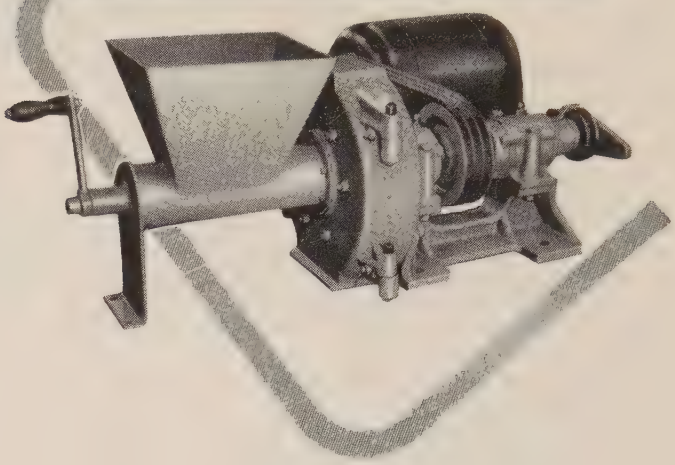

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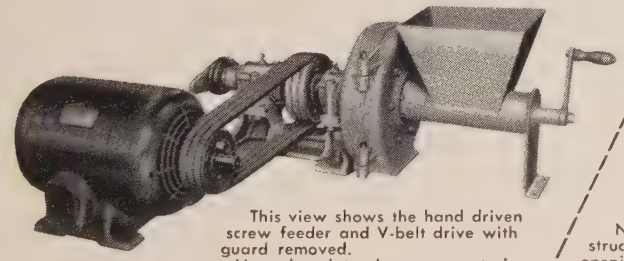
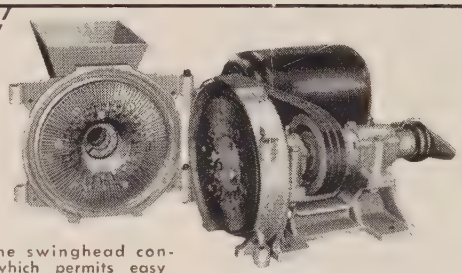


This view shows the hand driven screw feeder and V-belt drive with guard removed.
Note the plate clearance control at the tail end of the refiner. The micrometer indicator disc is graduated at 1/1000 inch intervals of plate clearance.



Note the swinghead construction which permits easy opening for washout and plate changes.
The screw feeder has interchangeable ribbon and solid screws. The ribbon screw can be seen in the center of the swinghead.
The plate pattern shown is used for fine refining and for pulp strength development.

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listed above, within a plant, naturally affect the silicate consumption, which varies from a low of 13.0 to 19 pounds per thousand square feet, double faced board, with the condition of the machinery being the prime factor in obtaining satisfactory silicate bonds with the paper stock being used. Due to the variances in absorption rates of various 9 points and liners, the glue rolls should be adjusted accordingly, to obtain the correct silicate pattern and bond. The incorporation of dial gage adjustments on modern corrugators gives the operators simple controls for varying his clearances. In all cases, the clearances should be checked at least once each shift.

The proper silicate bond should be uniform in cross section. A greater amount of silicate on one side of the bond than on the other, or the complete absence of silicate from one side of the bond, produces nonuniformity in the bond strength, such that it will be stronger when pulled in one direction than in the other. Lack of symmetry sacrifices some of the reinforcing action of silicate in increasing the stiffness and rigidity of the corrugated board. Contributing causes to the above are lack of synchronization between board speed and peripheral speed of the adhesive transfer roll and improper alignment between the fingers and the transfer roll. The former is sometimes difficult to overcome on a pressure-type machine while the latter usually requires a filling of the finger such that the transfer roll, when in position, is exactly centered in the finger relief. Machinery manufacturers are attacking both problems with the introduction of specially ground glue rolls and step-down motors for driving the glue rolls. Both of these new features also contribute to a reduction in throwing of silicate at high operating speeds.

While checking the cross section of the silicate bond, the operator should also look for nonuniformity, as occurrence of this condition is a source of weakness in the board, and failures under compression tests invariably occur at the breaks in the adhesive bond. Common causes of this type of bond are transfer or glue rolls out of round, worn and nonuniform corrugating rolls, wild caliper corrugating medium, use of too little silicate, or use of a silicate having either too great or too low a viscosity. In cases of worn equipment, the application of a greater amount of silicate, or one with a higher viscosity, can remedy this condition somewhat. The above is not recommended as good operating practice. The source of the trouble should be located and corrected. However, in the interim, silicate, due to its flexibility, can fill part of the gap.

With proper settings and maintenance, finger lines on single faced board can be practically eliminated. Should wide finger lines occur, the fingers and the finger jig should be checked, and those fingers which are worn or bent, replaced. Should the cause be due to silicate accumulation on the finger tips, the silicate should be removed by means of a finger scraper, a bent piece of flat bar stock with a slit on the end to conform to the finger. The application of extremely hot water through orifices in a pipe which is hung on a jig across the front of the machine between the pressure and lower corrugating roll, with an orifice opposite each finger, is quite effective. Plants which have two or more single facers, running alternately during each day, will find that the use of this simple device, as one or the other single facer goes down, will be very beneficial. As for coatings to be applied to the fingers, the laboratories of the various silicate manufacturers are continuing their research with newly discovered products, which should offer considerable improvement over those coatings that are in use today. A spare set of fingers and holders for each single facer, ready for replacement of worn or bent fingers, is strongly recommended.

The proper conditioning of the single facer liner and the corrugating medium is very important in the formation of a good silicate bond. Improper showering and tension control of the 9-point will give a non-uniform silicate bond due to poor fluffing. Too much preheat on the adhesive side of the liner will drive the moisture content of the board below that required for proper penetration and bonding of the silicate. When this occurs, reduction of the preheat, changing of the preheat wrap such that some of the moisture is driven toward the adhesive side, or the use of a steam shower on the adhesive side is required. Too little preheat, on high moisture content board, results in excessive penetration, little or no shoulders and the reverse procedures given for too much preheat, should be applied. The tensions on both liner and 9-point should be adjusted such that there is no disturbance of the silicate bond once the two components meet at the nip. The above adjustments require the use of common sense by the operator in making the adjustments in accordance with the roll stock which he is running.

Since silicate adhesives form a bond by the loss of water through absorption and evaporation, any conditions within the plant which interfere with the process hinder the quick bonding properties incorporated into the silicate. Many plants do not have hoods installed over their single facers to remove the excess steam and moisture escaping from the showers. Consequently, the setting of the silicate bond is delayed by the condensation on the single face board as it passes over the bridge. In addition, unless the plant is equipped with a large preheater on the bridge, the excess moisture will cause warping of the board at the cut-off.

The adhesion of silicate to the various metal component parts of the single facer can be greatly alleviated if certain simple procedures are followed. Large line-up charts, conveniently placed, will prevent misalignment as splices are made, thus preventing accumulation of silicate on the machine rolls. The use of corrugating medium, $^1/_4$ inch narrower than the liner, is also recommended. Glue roll wipers made of old printing dies, mounted in appropriate holders, attached to the frame of the machine and set to wipe the outside $^1/_8$ to $^1/_4$ inch will prevent silicate appearing on the rolls. These wipers should be set at an angle so that the bead, which is developed on the inside edge, runs off the outside edge of the wiper into the pan. The use of coatings on the rolls, either paraffin oil or Aquadag, is recommended. The former is applied either by oil cans or by means of wick wipers of several types. The latter can be sprayed or brushed on. The use of these coating materials, in addition to keeping the rolls practically free of silicate, also aid in fluffing. For around the frame, glue pan, and other nonheated parts of the single facer, the use of parting films, such as Boothcote, is very useful in reducing silicate clean-up. The periodic lateral movement of the bottom corrugating roll allows even wearing of the rolls and prevents the formation of nibs under the finger slots of the top corrugating roll. If allowed to form, these nibs will eventually cut the corrugating medium, thus allowing silicate to bleed onto the rolls.

The use of a separator and proper pump maintenance are two other factors which aid in the efficient use of silicate on the single facer. The former removes paraffin oil, paper, and other foreign materials from the silicate overflow, such that only clean material returns to the storage tanks for further use. All silicate pumps should be of all iron construction and have a water seal packing ring. A piece of small link chain draped over the pump shaft and running in a pan of water will prevent the crystallization of silicate on the shaft and the subsequent destruction of the pump packing, resulting in silicate leaks.

During my talk, I have concerned myself with the use of straight silicates on the corrugator because these predominate in the industry today. However, recent developments by various silicate manufacturers incorporating various additives are worthy of mention as preliminary results indicate that these new silicates have, in some cases, proved superior to both straight silicate and other corrugating adhesives with regard to both speed, bond, and over-all box quality. It could be that in the not too distant future, after certain modifications, they may prove to meet all the adhesive specifications desired by the corrugated board manufacturer.

THICKNESS CONTROL A PROBLEM?

Tracerlab Beta Gauges

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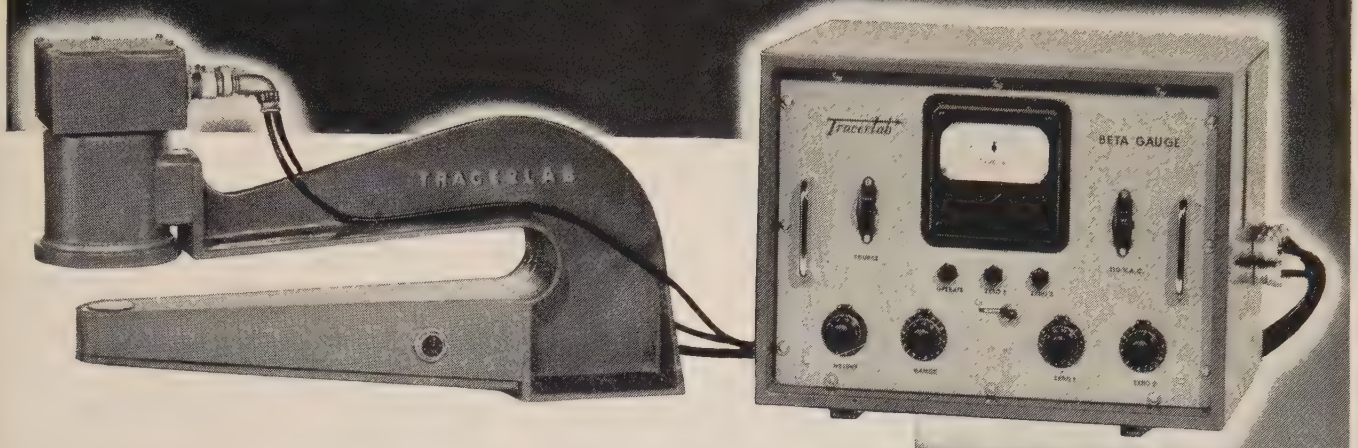

TRACERLAB's new model, non-contacting Beta Gauge measures and records the weight per unit area or thickness of sheet materials. Because beta radiation is used, a high degree of accuracy and sensitivity is achieved, unaffected by variations in chemical composition of the material being gauged.

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Notwithstanding these developments, straight sodium silicates, by their fundamental characteristics, offer the box-maker, the highest board quality, even though he may depart from the indicated optimum operating conditions. However, departure from top operating efficiency does not benefit anyone but only wastes materials, manpower, and results in a poorer product.

Efficient maintenance, periodic checks on the board produced and following the suggestions offered by the technical representatives of the silicate, machinery, and board manufacturers will enable each plant to produce high-quality silicate board at the lowest cost.

New England

The Annual Spring Meeting of the New England Section of TAPPI was held at the Griswold Hotel and Country Club, Groton, Conn., June 8 and 9, 1951. The theme of the meeting was "The Use of Statistics in the Manufacture and Converting of Paper" and although the total registration was not as large as anticipated, the sessions were very well attended.

There was no formal program Friday morning, the meeting starting with a luncheon at noon with Professor George E. Kimball of Columbia University being the featured speaker. Professor Kimball stressed that mathematics, in general, can and should be applied to a much wider range of industrial problems than is now the case. To illustrate his contention he cited several examples from his work on an operations research group attached to the Navy during the war. One of the main problems was to find methods of exploiting new equipment with which there was no experience. By an objective approach, acceptable results were obtained. They studied such projects as the plotting of probable submarine operations, size of convoys, training in aircraft bombing, efficiency of antiaircraft guns on merchant ships, and were able to come up with much valuable information. By the use of such an approach industry could benefit in the analysis of sales campaigns vs. sales budgets, location of warehouses, production scheduling where a balance of seasonal markets, costs, and inventory are important; machine maintenance schedules; and such other instances where a more accurate prediction of effects would assist management in the determination of its policies.

The next speaker was W. H. Coughlin, Director of Quality Control, Thompson Products Inc., Cleveland, Ohio, who spoke on "Breakdown of Variability into Resources, Identification of Causes." Mr. Coughlin announced at the outset that he was not a statistician and that he would but outline the broad principals of quality control. A start must be made by first determining the problem, then he suggested that qualified help be secured in that the mathematics are quite involved, then finally studying the results. Statistical quality control is not a cure-all; when properly used it will only indicate when a process is out of control or has a tendency to get out of control and will indicate an assignable cause. The design of the charts and procedures must be adapted to each application and may be more or less complicated. In each case the questions as to who, why, what, when, and where must be considered if satisfactory results are to be expected.

Geoffrey Beall, Professor of Statistics, University of Connecticut, Stons, Conn., was the final speaker at the afternoon session. Professor Ball by the use of an example, illustrated the development and use of control charts to establish variations in trend and variations in value. Of primary interest is the determination of chance variation. The difference in the values of successive points gives an estimate of the variability that must be tolerated. Running averages which cover a reasonable period of time will indicate a trend, the changes in which are probably not by chance. Professor Beall's paper will be published in another issue of *Tappi*.

Seated, l.–r.: Helen Kiely, H. W. Knudson, R. J. Proctor, Geoffrey Beall. Standing, l.–r.: John Langmaid, Jr., Prof. Kimball, Prof. Jenness, M. S. Renner, W. H. Coughlin, A. E. Bachmann, F. S. Klein, Harold Cobb, and A. G. Dreis

Before the meeting was adjourned, the Secretary, A. G. Dries, read his report, which was followed by the election of officers for the 1951–52 season. H. W. Knudson, Hollingsworth & Vose Co., East Walpole, Mass., was elected Chairman; F. S. Klein, Byron Weston Co., Dalton, Mass., Vice-Chairman; A. G. Dries, Hercules Powder Co., Holyoke, Mass., Secretary; and H. T. Barker, Bird & Son, Inc., Treasurer. The Executive Committee includes the following: Miss H. U. Kiely, S. J. Quattrocchi, G. L. Benson, C. H. Horton, W. C. Hunter, C. J. Backus, G. E. Soyka.

An informal banquet was held in the main dining hall Friday evening. A. E. Bachmann, the "Immediate" Past-President of TAPPI, extended his greeting to the group.

Saturday morning was devoted to a panel discussion, the members being introduced by Mr. Knudson.

F. S. Klein, Byron Weston Co., introduced the discussion "What Sampling Plan Shall We Follow?" in which he asked questions that are of special interest to the short-order operators. It was recognized that on a long run it was possible to set up a control chart, but on a short run by the time the machine has settled down, the order is completed without an opportunity to establish a pattern. Then he asked for an opinion as to the number of samples required for quality control.

In the discussion which followed the formal presentations, it was suggested that charts even on short runs would be of value as a guide for future orders on the same grade. One member stated that they had had some measure of success by holding up on short orders until a sufficient quantity had accumulated for a longer run.

During the discussion on sampling it was emphasized that the quality control chart indicated process control; and by studies of the variables which cause trouble, a sufficient history might develop so that effects could be anticipated. The number of samples is affected by the degree of control achieved. More samples are needed to establish the pattern with less as the machine is brought under control.

M. E. Blew, Strathmore Paper Co., East Springfield, Mass., in his paper "Applications in Beater Room and Finishing Room" cited the experiences of his company in the control of their broke. The defects were ascribed to the various sources and then tabulated into percentage figures which were used as a guide toward the improvement of operating conditions. By following up monthly they were able to correct several unsatisfactory conditions. They also investigated basis weight control. Among other effects they found that there was a decided variation between the runs of different machine tenders. Through statistical quality control they were able to reduce the basis weight limits which amounted to a savings in their subsequent converting operation.

"Why a Statistician?" was the subject taken by Maynard S. Renner, of the Dewey & Almy Chemical Co. Mr. Renner outlined the advantages of approaching a problem from the

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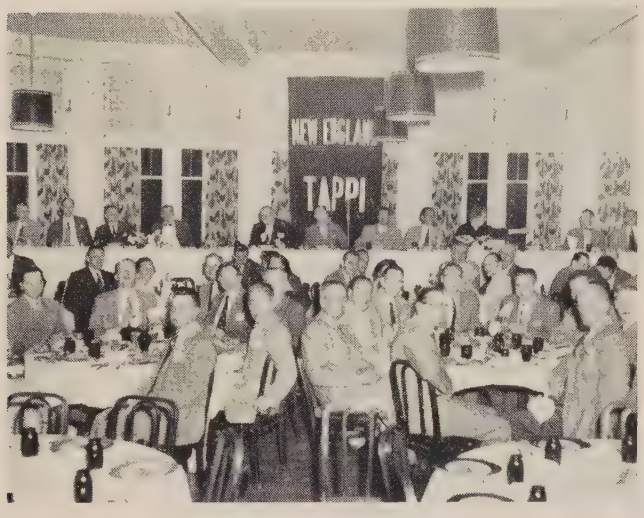
purely statistical standpoints. He also stressed the advisability of having an expert in statistics as a cooperator.

Mr. H. W. Cobb of the S. D. Warren Co. outlined their use of statistical quality control in paper mill experimentation, and Warren R. Purcell of the Brown Co., Berlin, N. H., outlined the procedure in the application of quality control to a specific paper saturation problem. It is expected that both of these presentations will appear later in *Tappi*.



Dinner at the Annual Spring Meeting of the New England Section, Groton, Conn., May 19, 1951

The final paper on the program was given by O. H. Somers, of the Western Printing & Lithographing Co. Mr. Somers' company prints 45% of the comic books printed in the United States and he spoke from the viewpoint of the paper user. They set up a quality control on their incoming papers using those properties of particular interest to them. They found considerable differences between paper from different sources and guided by their control work were able to work with the mills so that now they have a fairly uniform supply which has resulted in more uniform printing and lower ink costs.

One test which they found important was the ink receptivity which they measure by taking the light reflectance of the sheet after application and removal of K & N test ink. Using a 100 scale a difference of a point roughly could become a variation of $1000 in ink cost within a year. Because of the importance of sheet wettability in offset printing they found that TAPPI Routine Control Method RC-49 was also of considerable value to them. Illustrating his points with charts Mr. Somers showed how statistical quality control has become an important factor in their operations.

In the discussion period considerable time was devoted to sampling. One question was the possible variations between samples taken at the end of a roll vs. random sampling. Mr. Somers stated that their experience was that basis weight was generally well in control and that they sample from the outside of the roll. A trial in which samples were taken at different points within the roll did not show significant differences enough to warrant the extra work involved. It was stressed that there should not be confusion between a control sample and an appraisal sample. The first is applied to process only while the second is the evaluation of a product. Statistical quality control is only interested in variation within the process itself and not necessarily with product quality.

The statement was made that the paper industry is "test happy" and does not take advantage of their possibilities. It was admitted that the applications of statistical quality control to the paper industry was not easy but it was felt that a wider usage of charts rather than listed figures would result in better operating conditions.

There was a lunch to close the meeting Saturday noon following which several took advantage of the facilities of the hotel to play golf in the afternoon.

Why a Statistician?

Maynard S. Renner

This talk is intended to tell you something of what happens when one sits down with a statistician to discuss the planning of an experiment. Let me make it plain, however, that I am speaking strictly from the receiving end, not as a statistician, but as an experimenter, talking with general reference to the subject of laboratory experimentation. I want to give you some very definite answers to the question, "Why a statistician?" Anyone who has attended any recent meetings on application of statistical methods must realize that it is no longer even an open secret that we chemists aren't too skilled in handling problems in which variability is a major factor. Frankly, we are naive and clumsy in our efforts to cope with such problems. It is hard to say quite why—certainly our formal training hasn't been much help—I never heard of a designed experiment in college. We were taught to run two checks and average the result, or, all too often, to run three and average the best two out of three. That's what our training has been—away from the direction of recognizing that results can vary.

Of course, if we don't have to worry too much about variation, this approach is probably the best. There is no point in worrying about something that isn't important. But more and more there are times when variation is important, when it is the very thing that is bedeviling us and yet all too often we refuse to consider the fact that it can be there—that it can exist.

All too frequently we refuse to use our ingenuity to find ways of getting at it. Take the matter of sampling as an illustration. Over the past few months I have had occasion to discuss a lot of analytical results with various people doing testing work. I can find all kinds of data on reproducibility of a group of test results from a single sample but a general reluctance to consider that samples also might vary. When the existence of a sampling problem is recognized we generally dream up a complicated sampling scheme and then say, "Heaven knows, we are doing all we can about sampling" without ever realizing that we could at least investigate the reproducibility of the sample just as we do investigate the reproducibility of the test.

Walter Murphy in an article in the June 12, 1950, issue of *Chemical and Engineering News* on "Trends in Analytical Chemistry" points out that "analysts talk a great deal about the problem of taking samples but actually they have done very little about it . . . ."

Furthermore, we don't seem to have any way to handle data in which there is variability. There are some very simple and very helpful schemes for handling such data—frequency histograms, scatter diagrams, even the control chart is not too complicated. But usually the best we chemists can do is average, and how we can average. Some of you heard George Wadsworth at a meeting in Worcester 2 years ago point out that the average temperature in Boston over a period of 80 years is 50° but no one in his right mind would ever dress for 50° temperature in Boston in August or February. A lot of our averages leave us just that confused. All too often we end up with a lot of numbers on a piece of paper, look at them and say, "This is too much for me." Then we make an intuitive decision which may or may not be right, probably has the same chance of being right as if we hadn't bothered to collect the data in the first place. The only thing we gained from collecting the data is, we've established the fact that with the means at our disposal, it has been

Maynard S. Renner, Asst. Research Director, Dewey & Almy Chemical Co., Cambridge, Mass.

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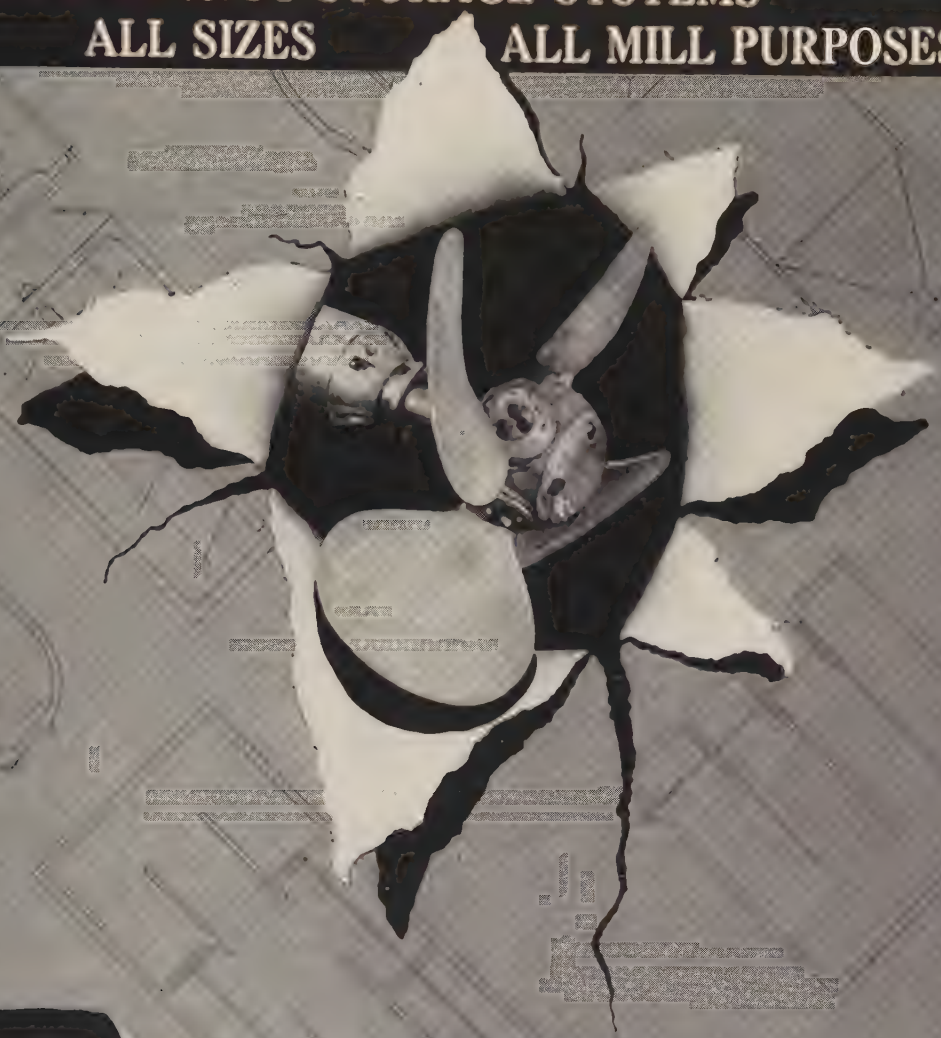

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impossible for us to get data sufficiently adequate to point to a clean-cut course of action in any direction. Sometimes, also, we get data that are not adequate to prove anything and then proceed to draw beautiful conclusions from it.

That is a sad catalog of deficiences but unfortunately it is all too true at one place or another for most of us and it indicates why a statistician can help us.

A statistician's business, in a sense, is variability. To put it crudely, variability is his meal ticket, more, in many cases his passion. His entire state of mind is such that he delights in running down sources of variability. I have talked to statisticians about variability problems that they thought they could get their teeth into and have seen their eyes begin to sparkle and their interest begin to come up like a fire horse at the sound of a fire bell.

Now I want to indicate some of the important things that happen when one sits down with a statistician to plan an experiment.

In the first place, a statistician is going to want your process to be in sufficient statistical control to give him assurance of a reasonable degree of predictability. He has efficient tools for testing for lack of control and equally efficient tools for running down sources of variability. If there is too much variability that hasn't been tracked down to any source in your process, more work will have to be done before he can tackle the planning part.

I remember my dismay the first time I ever took a problem to a statistician. It was a testing process and heaven knows there was plenty of variability in it but I thought that was what statisticians were for. I wanted to get busy testing products, but instead I was told that we had to get the variability out of the process first. We did it but it took a long time. It wasn't until many months afterward that the realization dawned on me of what a tremendous gain had resulted from finally getting this testing process operating so as to give predictable results—how many more things we could do as a result. Also, of course, small wonder I couldn't get satisfactory results out of the process full of variability as it had been if a statistician couldn't.

Then with respect to the technical details of an experiment. I am not referring here to questions of design *per se*. The value of design has been adequately demonstrated. Questions of design I'd rather leave to the statisticians to argue about. I refer more to the very important details of how much testing to do and where, an important item of cost these days.

I saw an experiment recently which was set up to find out if there was any difference between two different treatments in their effect upon the Mullen test of one kind of paper. The man who did the work was not a statistician but he was aware that Mullens could vary and that paper could vary in its Mullen strength. He had tried, or others before him had tried, to answer this question with small-scale experiments and without success. This fellow was hard-working, intelligent, not easily discouraged, and certainly not lazy. He wanted an answer and decided that a lot of data would give it to him.

He set up an experiment in which he compared the two different treatments at ten different levels or concentrations. This was a laboratory experiment so he cut a long sheet of paper off a roll and cut it into ten crosswise strips and used one crosswide strip for each level or concentration. He then cut each crosswise strip in half and used one half of each strip for each of the two treatments. He then cut each half strip in half again so as to give him two pieces of paper for each of the two treatments at each level or a total of forty sample sheets. These were then treated and 40 Mullens run on each treated sheet or a total of 1600 Mullens.

Now as it happens there are a number of things about this experiment a statistician might have pointed out, but I want to talk about the simple things. In the first place, the variability of the paper was at least as great as the variability of the Mullen test, so that he could have obtained just as much information if he had reduced the number of Mullens drastically. Furthermore, since it took no more actual working time to treat the paper than to run the Mullens, he could have got a good deal more information if he had increased the number of pieces of paper he tested. In addition, the preparation of the treatments at different levels was time-consuming, much more so than either treating the paper or running the Mullens. Fewer levels spaced more widely would have given him the same information that the ten levels gave him. For a good deal less work, and a lot fewer Mullens, this fellow could have obtained the same or more information, and that without resorting to any complex designs, which might have given him still more efficiency.

In addition, if this experiment or any such experiment were well designed by a statistician it would have yielded some quantitative information of great value about the variability of the experiment. By means of variance analysis with the data properly set up, it would have been possible to know at the end of the experiment how much each of the different elements in the experiment, treatments, concentrations, paper, Mullens, interactions, and over-all error had contributed to the total variability of the experiment. This point may seem slightly academic as I make it here but, believe me, it can be a great relief to look at a set of data broken down in this manner. I suspect also that in many cases where the error of the experiment is significantly large, knowing that it is large might save a lot of time needlessly spent in trying to get more concordant data or "better points"—time that might much better be spent in tracking down those sources of error which were what really threw the data off.

The final point I want to make is that when one sits down with a statistician to plan an experiment—the experiment really gets planned. Somehow in trying to verbalize, in trying to tell an outsider enough about the problem so that he can work intelligently in helping us to plan an experiment, our own thinking clarifies a lot. Maybe I am saying that we chemists don't even know about our own problems—but I don't think so. I think what I am saying is that it is a universal human characteristic for a person to get so bound up in his own problems that he can't see the woods for the trees, that trying to state them to someone else helps to get them in better perspective.

I do know, out of my own background and from others, that it is not a completely unusual experience to find that whereas, in the preliminary discussion of the planning of an experiment, each party to the discussion has his own and very decided opinions about what are the most important variables, the experimentation finally shows that the most important variable of all was one that nobody ever even mentioned or thought of in the preliminary discussion.

I also know that in my early days of discussions with a statistician, he used to ask me what I thought were the most foolish questions. My reaction would be to say immediately, "Why everybody knows that . . . . " and then gradually deflate with the growing realization that sure, everybody thought he knew, but nobody had the slightest shred of evidence to support what he thought he knew. Eventually, after checking upon some of these questions and finding them to have a perfectly sound basis, I came to realize that so far as my problem was concerned, I was talking to a real Man from Mars and came to put a very high value on this outsider's entirely new point of view.

This talk has attempted to indicate some of the things a statistician can do to help us. Incidentally, though the way of the self-taught statistician is known to be long and fraught with difficulty, this talk also indicates ways in which we can help ourselves a little even if we are not statisticians.

Gee, Mr. Smith... you say the funniest things!

Sec: I never worked for a paper mill before. You use the funniest words! "Railroading!" "Crush!" What do they mean?

Sup: They mean trouble . . . and plenty of it! When the nip squeezes water from a sheet faster than the felt can take it, the water "railroads" back toward the wet end until there's so much water trapped between the felt and the sheet that it "crushes" through the sheet.

Sec: Then "railroading" means water traveling back along the felt . . . and "crush" means bursting through the paper. Right?

Sup: Young lady, you've said it! And we lick "railroading" and "crush" by using the proper weave and weight of felt for the job.

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The Trist Paper Coating System

A. RONALD TRIST

A DESCRIPTION of the Trist paper coating system falls into three major phases, all three of which are necessary for the successful operation of the system. The word "system" or "method" is used because it is not entirely a process; rather it is a joining or combining of several processes. The first process has to do with the making of the coating emulsion; the second is represented by the special machine and physicochemical means to make this emulsion; and the third process consists of the application of the coating to the traveling web.

These three processes may be described in the order of their use and importance: (1) the coating emulsion; (2) the kinetic colloider, a special machine which makes the emulsion; and (3) the Trist coater, a special coating machine which applies the coating.

THE COATING EMULSION

The waterproof film surface treatment of paper webs consists first in the making of an oil phase emulsion; this is an emulsion in which the water is in the disperse phase and the oil, petroleum, or solvent is in the continuous phase. This portion of the composition can and does employ and contain a variety of pigments, white or colored, and also a wide range of resins from which to choose.

When completed, this emulsion complex is similar, so far as pigments, solvents, and resins are concerned, to a paint and/or a printing ink. The difference is that water is a component, as just stated, but it is water in the truly colloidal state, dispersed, and in suspension, with a very small particle size. The water is enveloped and surrounded, however, by the oil, petroleum, or solvent phase, in which both pigment and resinous binder are located. "Located" is the word which correctly defines the region where they reside and stay.

If the phases are reversed, making water as the outside or continuous phase, the coating emulsion can be applied to a paper web, provided such paper is highly sized, and provided the time needed for absorption of the water phase by such nonabsorbent paper is less than the rapid evaporation rate of the coating vehicles. The resultant film has exactly the same pigments, resins, and chemical agents, moreover, such an oil phase emulsion can become the disperse phase in a water phase emulsion under certain conditions of manufacture.

Indeed the composition is an emulsion of which there can be fundamentally two different kinds: one the mayonnaise type and the other that of a glass of milk. The mayonnaise has the oil phase or oil component on the outside; the milk has the butter fat of small particles surrounded by a watery medium. Preferably, however, the coating is made like mayonnaise, that is, the water particles are in the interior, covered by the outside oil, petroleum, or other solvents suitable for the resin binders which are always required.

Resin is the basis of the binder material. There are many resins, costly or cheap, light or dark, brittle or soft; the range is open for their adoption in these coatings in any proportions found desirable and for a wide range of different coatings to suit different conditions of use.

With reference to pigments almost any substance which is used in making paint or printing ink can be employed in the structure of the oil phase portion of the Trist coating composition. Among these substances are barium sulphate, magnesium silicate, calcium carbonate, lithopone, titanium dioxide, and a whole list of others.

When so compounded these emulsions, with 10, 15, and even 20% or more of water in the colloidal state, and in the disperse phase, can be treated as though they were simple oil dispersions in the making of another separate emulsion. In

A. RONALD TRIST, Trist Holdings Ltd., Canada; Trist Colloidal Products Patented, 420 Lexington Ave., New York 17, N. Y.

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this way an emulsion is created within an emulsion; this compounding thus produces a complex with advantages not obtained from an emulsion product which is not so compounded.

A reaction between two substances (polymerized linseed oil and magnesium chloride or other suitable salts dissolved in water) takes place slowly at and above room temperature, and continues after the composition has been made. This action goes on even during storage; observation shows that Brownian movement plays a part by its reactive activities, valuable in particular for stable products, such as paint and enamel; if it is desired to prevent settling of suspended solids, the thixotropic state can be induced.

The manufacture of the coating itself may be described briefly as the selection of a petroleum or solvent—kerosene, naphtha, or other suitable material to dissolve the resins or binding agents—plus pigments, dispersion agents, etc., as described.

The foregoing statements and results are the direct consequence of several combined phenomena. First, an interfacial surface tension depressant is present which permits high concentration of solids—65 to 70%, and in some low oil absorption pigments even higher than this. Moreover, a third phase structure arises in the emulsion coating from the presence of the small quantity of magnesium chloride and polymerized linseed oil—about 4 pounds to a ton of product.

This substance dissolved in the water combines chemically with the highly polymerized linseed oil which is made by boiling it in special deep kettles at a temperature of 600°F. By this means a long chain polymer is generated, coupled with the simultaneous generation of the two linseed acids—linolenic and linoleic.

These acids and the attendant polymers dissolved along with the resin-petroleum or other solvent vehicles combine slowly, and at moderate homogenizing temperatures, with the linseed complex at the interface of the magnesium chloride charged water particles. Their surrounding oil phase envelope forms an insoluble elastic follicle or film autogenously created during homogenizing. This film is completely insoluble in both the water and oil phases from which it derives or originates.

A continuing action similar to that of light on a photographic film only partly exposed is a simple analogy which roughly defines the continuing action after the emulsion is made. As is well known, this action takes place in the photographic plate after it has been underexposed; even when much underexposed, continuing light action goes on even in the dark.

This chemical reaction constitutes the third phase or film separating the two normal existing oil and water phases. The result from this structure is good suspension of pigment, added stability of the emulsion, and the means to produce a thixotropic condition with its attendant advantages, particularly in the manufacture of paint, printing ink, and some coating films.

A suedelike mat surface has proved so satisfactory that so far it has been perfected in preference to the usual gloss finish of some coatings; however, gloss coatings of varying surface characteristics can also be made as emulsions and applied to a web. The United States patent covering the emulsion embodies such surface characteristics as, for example, scratchproof, highly brilliant, or softer but still glossy coating.

Such differences in character derive from the kind of resin binders and the class of pigments. One can visualize this better by thinking in terms of a range of paints which also depend for their surface character upon the ingredients of which they are composed, always remembering that Trist coatings invariably contain water in the truly colloidal state, thus inducing the various phenomena described.

Since the rapid drying of the coating is mainly due to its emulsion character, the greater the surface area of the ve-

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hicles and the smaller their particles, the more rapid is their evaporation. Recently a 22-pound paper was coated with a dry weight of $7^1/_2$ pounds per ream of 3000 square feet, or 15 pounds per ream for the two sides; therefore, the range in weight is from $1^1/_2$ to $7^1/_2$ pounds on 3000 square feet of paper.

Research has shown that many water-soluble dyes, when used as the coloring matter in such a composition, are rendered insoluble, precipitated, and become mordanted or fixed, having migrated to the oil phase part of the emulsion, leaving the water free of the dye in which it was dissolved. Moreover, in this new state some fugitive dyes are no longer fugitive and become fast, or more fast to light than they were in the solvent state. The technique for engendering these results is available to all users of the Trist system.

KINETIC COLLOIDER

The second phase of the Trist system has to do with the special machine or mill which makes the coating emulsion and which is known as the "kinetic colloider."

This machine which has been specially designed for making these emulsion coatings has some novel but necessary features. The mill, as it may be called, is of the totally enclosed type, that is, the emulsion does not come in contact with the atmosphere until heat extraction and pressure reduction have both reached a predetermined condition or degree.

In this way the smallest and most highly homogenized particles are kept in the product and are not lost by evaporation which otherwise would be the case with such a fine state of subdivision. The wetting or complete covering of all pigment particles with the resin petroleum solution is accomplished; therefore, this mill completely homogenizes the mixture of pigment, solvent, binding agent, and water, producing the coating composition ready for putting on the paper web.

THE TRIST COATER

The final stage of this paper coating system consists of a specially constructed machine to apply the coating, known as the "Trist coater." A special machine is required because a hitherto unused method of applying coating to the surface of a web is employed.

This machine depends fundamentally upon the use of a flexible trailing blade, usually of spring steel which rests under tension against the periphery of a rubber-covered roller. The blade which acts as a scraper or doctor is placed at an angle to the roller somewhat analogous to the way a squeegee is used to remove the wash water in cleaning a window; this coating blade does *not*, however, scrape or remove the coating emulsion. On the contrary, it spreads a very thin layer of emulsion evenly on the web.

This non-scraping action, contrary to the squeegee effect, results partly because the above-mentioned flexibility of the blade is complemented in its action by the resilient rubber roller covering. This result is described in the patent claim as the yielding cooperation of the flexible blade and a resilient bed or surface.

Such a function spreads and distributes the coating which is exceedingly thin and remarkably even. The final coat can be—and is—controllable from $1^1/_2$ to $7^1/_2$ pounds per ream of 3000 square feet. An additional factor in this operation is the presence of electrostatic surface charges. The coating is of opposite polarity to that of the paper surface.

Such thinness of surface-applied coating is the reverse of conventional coatings both in weights and in thicknesses. Two interesting differences arise from the method being described: One is the high speed at which the operation is conducted, ranging from 1000, 2000, or even 3000 lineal feet per minute; the second lies in the fact that the paper is not water wetted since the emulsion is in the oil phase or, in American technology, water in oil. As a result, the need for drying tunnels or festoons is eliminated.

The splitting of the emulsion as it makes contact with the paper exposes to the air the extensive surface area of the par-

ticles of water. Necessarily the equally attenuated thickness and large area of the oil plus pigment enveloping film also promotes rapid evaporation.

The surface left on the web by the coating composition and by the action of the blade is resilient, smooth, and slightly elastic; in this respect it is comparable to the surface of velvet and so lacks the rigidity of a supercalendered surface. Thus more perfect contact between the printing plate and the paper is permitted, giving higher quality in illustrations printed on such a surface.

Supercalendering is not necessary. When a semigloss or a still flatter contact face is desired, for example, as in rotogravure printing, the further passage of the paper web under a similar elastic blade—heated or not—and the resilient bed, or even under a buffing roller, can be included in the process and can be done during the winding or reeling of the paper roll.

The final operation consists in rereeling the fully dried coated paper by the standard high speed rewinder apparatus in general use for rereeling paper rolls. Since the web has not been wetted by water, no crinkling or creasing takes place; there is the added advantage that the strength and smoothness of the paper are preserved by not suffering the effects which absorption of excessive moisture would cause, if present.

PRESENT STATUS OF THE TRIST COATING SYSTEM

The Trist system of coating paper has been in successful commercial operation for some time. Paper of any weight or type can and is being coated by this method; among the different kinds are paper used for books, magazines, catalogues, bread wrapping, and labels, as well as cardboard.

An interesting experiment with a special coating has shown possibilities of some importance in the field of offset printing papers. Tests have proved that application of a special transparent, waterproof emulsion coat produces an advantage when printing, especially in multicolor work; such an application does not, however, change the appearance of the paper.

The reason is that the sheet so treated is immune from the action of the water used in the fountain of the offset press. The film also prevents the absorption of the ink into the fibers of the paper leaving the ink on the surface of the coating film with the consequent maintenance of the brilliance of the printing ink. At the same time the film entirely obviates loss of register of any of the images with relation to one another in color printing preventing expansion or shrinkage of the sheet between printings.

In other words, the coating provides dimensional stability of a high order, gives the printed image greater brilliance, and requires roughly just half the amount of printing ink to produce the image. Logically, this is to be expected as the result, whatever ink is employed, because it is held and absorbed by the almost invisible coating. Moreover, none of the ink can—or does—reach the actual fibers of the paper stratum below the level of the coating film.

In letterpress printing the coating is of distinctive appearance. It not only alters the surface condition but holds the ink and does not permit its absorption below the coating itself which of course is highly attracted to and by the printing ink; neither does the ink spread as occurs in some glazed papers.

Recent trials have demonstrated that it is now commercially practical to coat newsprint at small cost. This development is of major importance not only to the publisher but especially to the advertiser for the reason that the sharpness of the printing is greatly enhanced and much more attractive illustrations may be produced on coated paper. Some manufacturers of newsprint, publishers, and their advertisers are now thinking in terms of coated newsprint as an accepted development of the near future.

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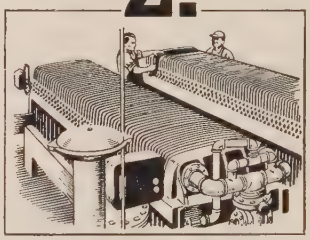
Dicalite materials are more than fillers. A good number of mills use them for their proved effectiveness in aiding production as well. In board mills, for example, the chief advantage is improvement in sheet formation without increasing density and with faster drainage. Dicalite also increases liner coverage, often with improved brightness. In fine paper mills improved formation, saving in bleached sulphite pulp, and improved retention of titanium pigment are the salient benefits. Tissue and toweling mills find Dicalite affords pitch control, and at the same time secures uniform density.

2.



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A filtration system using Dicalite filter-aids, which will afford continued re-use of practically all machine water can be employed successfully on most board, pulp and paper machines. One large board mill, operating two of their four machines on a closed system, filters and re-uses all the machine water. They report savings in power and steam alone are sufficient to pay materials and operating costs, while realizing in addition the recovery of fine fibers as well as appreciable increase in felt life.

TECHNICAL DATA on both the above uses of Dicalite materials will be sent on request. A Dicalite Engineer will gladly be of any additional service possible.

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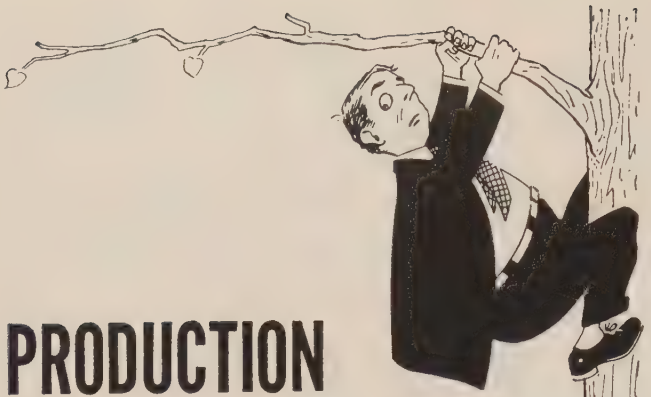

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In conclusion, the outstanding features of the Trist paper coating system may be summarized as follows:

1. Rapid drying at high speed which leads to greatly increased production.
2. A paper of high dimensional stability under varying atmospheric conditions.
3. Elimination of the necessity and cost of supercalendering.
4. A great variety and range of coatings distinct and different from those which are generically standard water mixtures of china clay, starch, or other water-soluble binding agents.
5. Hitherto unknown economies when compared with the cost of coating paper by conventional methods.

RECEIVED June 19, 1951. Presented at the Second Coating Conference of the Technical Association of the Pulp and Paper Industry, Boston, Mass., April 18–20, 1951.

RECENT BOOKS

Paper Year Book—1951. Edited by Anita Reinig, Davidson Publishing Co., 405 E. Superior St., Duluth 2, Minn. Cloth, $8^1/_2 \times 11^1/_2$, 625 pages. $10.

The ninth annual edition (1951) of the Paper Year Book is larger than the 1950 edition and represents a revision of the information supplied in earlier issues, together with a number of additions of new products, charts, and tables. More than 1000 kinds of paper are mentioned. The book is illustrated with over 700 photographs. A thumb-indexing scheme assists the user of the book. Data are given on coarse papers, printing paper, nonpaper items, paper manufacture and testing, and paper markets.

Economics of the Printing Ink Industry. By Robert S. Aries, Polytechnic Institute of Brooklyn, and Anthony Nickolaus, Sinclair & Valentine. R. S. Aries & Associates, New York, 1950. Paper, $6^1/_2 \times 9$, 108 pages. Photo-offset. $5.00.

A survey of the printing industry in the United States covering its history, firms in the field, raw materials, manufacture, character of inks, relation to the paper industry, technical developments, and future outlook. Dr. Aries who is a prodigious worker and an expert in the field of market analysis has produced another of his comprehensive reports. Since he relates many of his facts to the paper industry this publication is in a sense, by reflection, a guide to individuals interested in certain aspects of paper marketing.

The Analytical Balance. By William Marshall MacNevin, Professor of Analytical Chemistry, Ohio State University, Sandusky, Ohio. Handbook Publishers, Inc., 1951. Cloth, $5^3/_8 \times 7^3/_4$, 60 pages. $1.50.

This is a monograph that provides practical information about the care and use of the modern analytical balance. It is arranged to acquaint the average scientific worker with the problems of selecting, mounting, clearing, adjusting, testing, and repairing a balance. It is of particular value to laboratory directors, research workers, and teachers. It contains a list of manufacturers of analytical balances. When it is realized that the average G.I. must devote himself everlastingly to keeping his firearms in perfect order, the importance of this book becomes apparent. Since the balance is nearly the most important tool in the analytical procedures, the book was written at the request of many research workers and teachers.

Qualitative Ultramicroanalysis. By Paul L. Kirk, Professor of Biochemistry, University of California. New York, John Wiley & Sons, Inc.; London, Chapman & Hall, Ltd., 1950. Cloth, $5^1/_2 \times 8^1/_2$, 310 pages. $5.00.

Chemical journals are devoting more and more attention to microchemical analysis techniques. Nuclear chemistry has been a tremendous driving force in advancing this new field of science and technology. The biochemists have also been a leader in its utilization. As noted by the title the present volume deals with the ultra in microchemical analysis. In fact, the term "microgram" has come into use.

Dr. Kirk's book is made up of chapters that might appear in any book on analytical chemistry volumetric methods, titrimetry, etc., but the samples are in the 0.001-mg. range.

Water Treatment. By Eskel Nordell, The Permutit Co., Reinhold Publishing Co., New York, 1951. Cloth, $6 \times 9^1/_4$, 526 pages. Illustrated, $10.

Mr. Nordell is well known to the pulp and paper industry and was one of the authors of TAPPI Monograph No. 1 on "Industrial Water." There are few, if any, better informed technologists in the field covered by his book. It was written as a comprehensive work on industrial waters to serve the needs of executives, consultants, engineers, chemists, and operating personnel.

Although brief consideration is given to individual industries, Mr. Nordell refers to TAPPI's specifications relative to tolerance in water used by the pulp and paper industry. In general his text treats the subject of industrial water on a fundamental basis, covering such subjects as dissolved mineral matter and gases, turbidity, color, taste, odor, microorganisms, boiler feedwaters, aeration, chemical feeders, ion-exchangers, silica removal, lime-soda water softening, sedimentation, and zeolites.

It is a timely publication and reference to its contents will obviate much literature research.

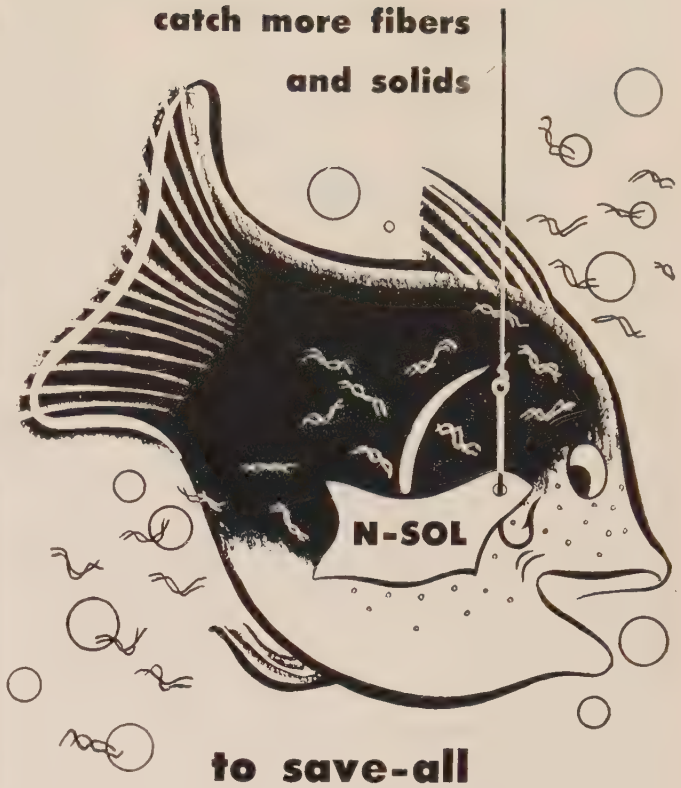
Natural and Synthetic High Polymers. 2nd Ed. By K. H. Meyer, Professor of Organic Chemistry, University of Geneva, Switzerland. Interscience Publishers, Inc., New York, 1950. Cloth, $6 \times 9^1/_2$, 891 pages. $15.

This is the fourth volume in the High Polymers Series and is a complete revision and enlargement of the 1942 edition. It is a basic text and is familiar to most individuals that are interested in the high polymers field. The author attempts to review the whole of the available material from a critical standpoint. As in the earlier edition the chapter headings remain as originally established, featuring in organic high polymers high polymeric hydrocarbons, ethers, esters, sulphides, etc., animal and vegetable polysaccharides and lignin, proteins, high polymers insolution, elasticity, viscosity and plasticity, films, foils, and membranes.

This book is a must for workers in the field of plastics and high polymers.

The Chemical Formulary. Vol. IX. By H. Bennett and a Board of Editors. The Chemical Publishing Co., Brooklyn, N. Y., 1951. Cloth, $5^1/_2 \times 8^1/_4$, 648 pages. $7.00.

This ninth Chemical Formulary scarcely needs a review since its predecessors are well known to the industry and to the public. Since nearly everyone is more or less of a specialist it is evident that when he needs information outside of his field of interest the job of finding a quick answer is important. Encyclopedias supply basic information of importance but the formulary goes further and more often than not gives a direct answer to the immediate problem whether it deals with adhesives, cements, colloids, inks, leather, lubricants, paints,



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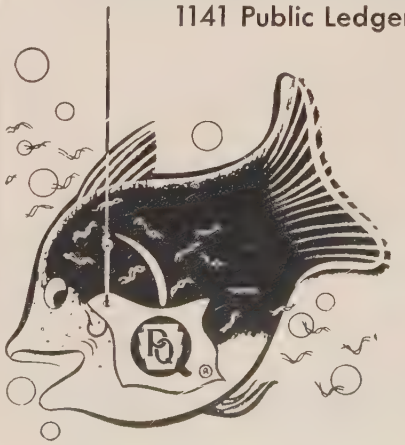

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"the Bauer story on Sulphite"

○ Three sets of samples are included in the treatise bearing the above title. The tabs are actual samples of products made in pulp and paper plants.

Seven samples in one set are products resulting from disk-milled knotter and fine screen rejects.

Five samples in another set are swatches made from sulphite pulp refined in disk mills for newsprint.

Eight samples in the third set are swatches of paper made from disk-refined screened sulphite.

Not only are the samples interesting in themselves, but they are illustrative of data on freeness, mullen test, tear test, power consumption, and tonnage capacity. Information on high-yield sulphite pulp is also included.

Now, of course, there's considerable work connected with collating "The Bauer Story on Sulphite." So we don't wish to send copies out to people who are merely curious; but we'll be glad to send a copy, upon request, to anyone who is actively engaged in the production of sulphite pulp or paper. Be sure to ask for a copy if you qualify.

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P138-51. Project Engineer for plant in East. Mechanical engineer or pulp and paper graduate up to 35 preferred. Should have experience on paper machines making coarse products, stock preparation, and converting equipment.

P139-51. Young man 25–30 to train for sales position with wire manufacturer. Experience in paper industry desirable. Considerable travel.

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E101-51. Chemical engineer. 30. Family. Five years' diversified pulp and paper experience in control, engineering, and development in newsprint, sulphite, soda, groundwood, and waste paper. Presently employed. Desires position in production or production development. Prefer location in West or Midwest.

E130-51. Top flight Corrosion Engineer. Technically qualified with broad experience in consulting, maintenance, specifications, and fabrication. Can cut high replacement costs by cooperating with engineering and operating departments. Age 42. Family. Chemical Graduate, metallurgical experience. Have made special study of digester corrosion problems for several pulp mills.

E131-51. Chemist. Married. Experience in general mill problems, process and technical control, felt and wire problems. Presently employed.

E132-51. Fourteen years' experience in paper manufacturing as chemist in fine paper mills and technical superintendent of fourdrinier, sulphite, kraft, and groundwood operation. Can handle stock problems of wide variety of furnishes, plan and supervise installation of papermaking equipment.

E133-51. Technical Salesman. Married. B.S., age 31, interested in maintaining contacts in Midwest paper mills through new affiliation. Excellent technical background and proved sales ability.

E134-51. Technical Director or Assistant Production Superintendent. Broad experience in technical and practical phases of fine papermaking. Presently employed.

E135-51. Sales Service Engineer. College graduate, with 20 years' experience in varied paper mill supplies desires position. Presently employed in a technical capacity but would like to return to the paper industry.

E136-51. Paper, printing, and printing inks. Supervisory and administrative experience combined with technical and practical training. Desires managerial position, sales or production.

Instrumentation Studies. LXIII. Erasability of Paper

III. Progress Report on a Study of Erasability. 2

W. A. WINK, N. J. BECKMAN, and W. P. RANEY

This progress report presents (a) a study of the erasing characteristics of six different papers which, in effect, is a continuation of the work reported in Instrumentation Studies LXII (2) and (b) a study of the various factors relating to erasability. Throughout the course of this work, the erasures were performed with an abrading machine designed specifically for this investigation. In the study of the erasing characteristics of the six additional papers, all the specimens were abraded for the number of strokes required to remove a pair of ink lines from the paper. Abraded and unabraded specimens were subsequently evaluated to determine the effects of erasure on weight loss, reflectance (R_∞ and R_0), gloss, and writing quality. The investigation of the various phenomena of erasure included a study of (a) the performance and uniformity of 21 Calibrase abrading wheels, (b) the abrading rates as the erasure proceeded from the surface of the paper into the body of the sheet, (c) the effect of speed of the abrading stroke, (d) the effect of vertical thrust of the abrading wheel on the paper, (e) the effect of repeated erasures on erasability data, (f) the effect of ink composition, and (g) the effect of relative humidity. Coincident with the study of the foregoing variables, an interesting phenomenon concerning the inherent structure of paper was discovered. Strong directional effects were apparent in the erasure of some papers which are attributed to a "shingled" effect of the fibers in the sheet (the directional effects are those associated with the change from machine to antimachine direction of erasure—not from machine to across-machine direction).

In the general discussion of erasability, presented in Part I of this series (*1*), the various factors which are called into play in the judgment of the erasing quality of paper were listed and studied. In that discussion it was concluded that many of the factors relating to erasability are not yet adequately defined nor are they in some cases amenable to scientific definition and measurement. This condition strongly emphasized the need for more knowledge concerning the phenomena of erasure, and it was indicated that the initial phases of the study would be conducted with research equipment; it is the hope and the plan that this study will eventuate in an improved definition of the factors that are basic to erasability and also in instrumentation suitable for the laboratory evaluation of this property.

To initiate our study of the various phenomena of erasability, the abrading machine described in Part II (*2*) was designed and constructed. This abrader, meant to be purely a research tool, embodies features that provide a wide range of flexibility and a means for abrading a relatively large surface of the paper. The important aspect of the latter is that it enables one to evaluate the changes in the physical properties of the paper produced by erasure.

Briefly, the principle of operation of this machine is one in which the reciprocating motion of the shaper ram causes a circular erasing wheel to move back and forth over the surface of the paper. Through the action of a pair of one-way brakes, the abrading wheel is locked, to prevent rotation, on the forward stroke; whereas for the back stroke (the non-erasing stroke), the brakes release and thus allow the wheel to roll freely. To obtain abrasion over a relatively large surface, the abrading machine is equipped with an automatic cross-feed mechanism which is synchronized with the non-erasing stroke. This mechanism causes the sample to move in a direction perpendicular to that of the erasing wheel in such manner that successive erasing strokes are made on different areas of the paper. The length and speed of the abrading stroke, the travel of the cross feed, and the vertical thrust on the abrading wheel are all adjustable over an appreciable range.

For the exploratory phase of this study on erasure, 23 samples of paper, supplied by manufacturers of writing paper, were abraded with the abrader just described and then evaluated. The physical tests performed on the abraded and unabraded samples of paper included weight, caliper, reflectance (R_∞ and R_0), a special low angle gloss, and writing quality.

To continue the work that had been started (Part II), six additional papers, obtained from two different manufacturers, were abraded and evaluated, the results for which are presented in the following section of this report. Following the completion of the exploratory work, our attention was directed to a study of the variables and factors relating to the property of erasability. It is the main purpose of this progress report to present the results of our investigation of those variables that have been studied thus far.

CONTINUATION OF EARLIER WORK

The exploratory study involving the six additional new papers was carried on in the same manner as that already described in Part II of this report. However, for the reader's convenience, brief descriptions of the procedures employed for abrading the samples and obtaining the physical data are again presented.

The samples were conditioned and abraded in a room conditioned at 50% relative humidity and 75°F. Those physical tests which would be affected by temperature and relative humidity were also made in the conditioned atmosphere. Prior to abrading the samples, two aqueous ink* lines were ruled on the specimens, 1.5 inches

W. A. Wink, Member TAPPI; Technical Associate; N. J. Beckman and W. P. Raney, Assistants, The Institute of Paper Chemistry, Appleton, Wis.

* Sanford's Premium Writing Fluid, manufactured by the Sanford Ink Co.

Table I. Description of Samples and Degree of Erasure

Sample	Description	Number of strokes[a]		Weight loss, mg.	
		In	*Across*	*In*	*Across*
25	Drawing, 100% rag	965	750	76.8	83.2
26	Bond, 50% rag	765	803	74.8	66.6
27	Bond, 25% rag	945	952	74.9	70.6
28	Drawing, 60% rag	216	255	68.5	84.5
29	Drawing, 100% rag	285	306	77.8	87.0
30	Drawing, 100% rag	285	231	54.1	79.0

[a] This is the number of strokes over any given point in the erased area (not the total number of strokes over the whole area).

apart, with a special rotary pen, developed and described by Schur and Levy (*3*). This pen provides a means for applying the lines in a reproducible manner, thus largely eliminating the variables inherent in methods employing an ordinary steel or draftsman's pen. Following application of the ink lines, the specimens were further conditioned in the atmosphere of the humidity room for a minimum period of 24 hours prior to abrasion.

As in the previous work, "Calibrase" abrasion wheels (No. CS17F), manufactured by the Taber Instrument Co., were used for abrading the specimens. The abrading machine was adjusted to abrade an area approximately 3 inches square and the erasures were performed with a vertical thrust of 555 grams on the abrading wheel.

Following abrasion of a specimen, two pieces, each 2.5 inches square, were accurately cut from the specimen—one from the central portion of the abraded area and the other from a portion lying in a region adjacent to the erased surface and in the same machine-direction zone of the paper. The specimens obtained in this manner were subsequently tested for weight, reflectance, low angle gloss, and writing quality in accordance with the methods described in Part II of this report.

Two specimens of each sample were abraded on the felt side with the same abrading wheel, one specimen with the erasing stroke parallel with the machine direc-

Table II. Effect of Erasure on Reflectance

Sample	Erasure in machine direction					Erasure across machine direction				
	Before		After			Before		After		
	R_∞	R_0	R'_∞	R'_0	$R_0 - R'_0$	R_∞	R_0	R'_∞	R'_0	$R_0 - R'_0$
25	92.4	83.1	84.6	75.0	8.1	92.2	83.0	85.5	75.6	7.4
26	82.7	71.5	75.7	61.8	9.7	83.0	71.9	75.8	63.3	8.6
27	78.9	70.9	72.1	61.4	9.5	78.9	70.8	72.4	62.4	8.4
28	72.2	71.6	71.5	70.8	0.8	72.1	71.4	71.1	70.3	1.1
29	69.9	69.7	68.5	68.2	1.5	69.8	69.7	69.4	69.2	0.5
30	87.9	74.7	85.1	70.8	3.9	88.1	75.7	85.9	70.6	5.1

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Table III. Effect of Erasure on Gloss

Sample	Erasure in machine direction					Erasure across machine direction				
	Before		After			Before		After		
	In	Across	In	Across	Ratio	In	Across	In	Across	Ratio
25	5.8	5.0	26.9	15.0	3.9	5.0	5.2	20.0	14.2	3.4
26	8.6	7.0	24.4	13.6	2.4	8.3	10.3	25.2	16.9	2.3
27	8.3	6.8	23.6	13.1	2.4	6.6	8.6	23.5	15.4	2.6
28	26.2	24.5	11.0	8.0	0.4	22.8	28.4	10.0	8.0	0.4
29	20.9	18.8	16.4	10.2	0.7	17.9	19.0	6.2	6.0	0.3
30	66.0	58.8	13.1	9.2	0.2	52.0	57.9	8.8	7.1	0.1

tion of the paper and the other with the erasing stroke perpendicular to the machine direction. Each specimen was erased just sufficiently to expunge the ink lines, and the number of strokes was recorded. The point at which erasure was considered complete was taken when the lines were almost completely obliterated; only a very weak trace of the lines remained.

The results of the physical measurements obtained for the six samples are presented in Tables I, II, and III. Examination of these data reveals that they are not outstandingly different from the results obtained in the earlier work. It will be noted from Table I that the number of erasing strokes required to expunge the ink lines varied from a minimum of 216 for sample 28 to a maximum of 965 for sample 25. By way of comparison, the number of erasing strokes necessary to obliterate the lines in the previous work varied between 57 and 1500 strokes. Taking the number of strokes as a criterion for judging the ease of erasure, these samples fall in an intermediate classification. As observed before, these data indicate that the direction of the erasing stroke had relatively little effect on the number of strokes required to remove the ink lines.

The amount of material removed by erasure varied from a minimum of 54.1 mg. for sample 30 (for specimens 2.5 inches square) to a maximum of 87.0 mg. for sample 29. These weight loss values are of the same order of magnitude as those presented in Part II, where they covered a range from 51.7 to 117 mg.; these new values also emphasize the fact that the range in weight loss is surprisingly small and, therefore, are suggestive of the possibility that the depth of penetration of the ink in the various samples does not cover a large range. An interesting observation in this respect is that the amount of material removed from sample 25 is about the same as that for the remaining samples, although this sample had the characteristics of an extremely hard-sized surface. Considerable difficulty was encountered in applying the lines to this paper and it was found to be impossible to rule a continuous line. The ink receptivity, as compared with the remaining five samples, was definitely inferior.

Table II presents the reflectivity values R_∞ (reflectance of a specimen backed by a thick pad consisting of the same paper as that of the specimen) and R_0 (reflectance of a specimen backed by a black body) obtained

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with the G.E. recording spectrophotometer at a wavelength of 555 mmu. Upon examination of these data it will be observed that, in most cases, erasure had a pronounced adverse effect on the reflectivity R_∞. The observed decrease in R_∞ varied from a minimum of 0.7% for sample 28 to a maximum of 7.8% for sample 25. In the previous work, the decreases in R_∞ fell between 0.8 and 12.1%. These are pronounced effects when it is considered that the eye is capable of distinguishing differences of the order of 0.5 to 2.0%. R_0 provides an approximation of the luminous reflectance of a single sheet of paper without backing. In noting these values, the minimum and maximum changes of 0.8 and 9.7% are for samples 28 and 26, respectively. Corresponding differences in the previous work ranged from 1.9 to 14.1%. An over-all comparison of these differences $(R_0 - R'_0)$ further reveals that, of all the papers investigated, sample 28 exhibited the smallest change in luminous reflectance.

The results of the gloss measurements obtained with the special low angle glossmeter are presented in Table III. The data obtained on the original specimens, before erasure, are presented in columns 2, 3, 7, and 8 and the data obtained on the specimens after erasure are presented in columns 4, 5, 9, and 10. The ratios calculated by dividing the average of the "in" and the "across" readings obtained on the abraded specimens by the average of the "in" and the "across" readings obtained on the unabraded specimens are presented in the sixth and last columns. A ratio of 1 indicates that the gloss of the sample was not changed by the abrading process. Here, as in the previous work, it will be observed that erasure had a pronounced effect on the gloss of the various papers. The gloss ratios for all the papers evaluated thus far, including those used in the initial phase of this study, varied between 0.1 and 3.9. The former value was obtained for sample 30 which exhibited the greatest decrease in gloss; the latter was obtained for sample 25 which showed the largest increase in gloss caused by abrasion.

The writing quality of these papers was judged on the appearance of a pair of ink lines that were ruled on the specimens after the specimens had been abraded for the number of strokes required to obliterate the original set of lines. In general, it was observed that the writing quality of those samples having a gloss ratio greater than one was superior to that of the samples having a gloss ratio less than 1. The degree of feathering was slight for samples 25, 26, and 27 and was most severe for sample 30; the smallest amount of feathering was observed for sample 25. Abrasion disrupted the surfaces of samples 28 and 29 to the extent that the ink lines were very irregular. The disrupted surface and the heavy fuzz caused the pen to "skip" as the lines were being ruled; thus, the lines were badly broken and lacking in continuity. These two samples, however, showed very little feathering. The photographs presented in Fig. 3 of Part II (*2*), which show the characteristics of various abraded surfaces, are quite typical of the results obtained for this set of six papers.

PERFORMANCE, UNIFORMITY, AND REPRODUCIBILITY OF ABRADING WHEELS

Uniformity and reproducibility of the abrading wheels have been of relatively small importance in the ex-

Table IV. Data on Reproducibility of Abrading Wheels
216 Strokes over Any Given Point in the Erased Area

Abrasion wheel	Specimen	Weight, mg. Original	Weight, mg. Loss
1	1	314.7	87.8
	2[a]	307.0	69.1
	3	306.9	74.9
2	4[a]	306.3	76.6
	5	307.9	84.8
	6	309.4	80.8
3	7	305.7	57.1
	8	309.7	59.8
4	9	305.8	77.5
	10	304.7	74.5
5	11	313.8	63.6
	12	305.1	61.5
6	13[a]	303.4	65.7
	14	300.9	67.3
	15[a]	304.3	65.5
	16	308.9	66.9
7	17	302.0	72.8
	18	305.2	73.1
	19[a]	300.7	70.9
	20[a]	301.3	63.2
8	21	300.8	67.7
	22	299.4	69.4
9	23	309.1	63.2
	24	309.8	70.5
10	25	311.3	81.7
	26	303.6	77.6
	27	302.8	67.3
	40[a]	303.2	68.9
	41[a]	304.2	69.0
11	28	302.4	69.7
	29	305.7	70.7
12	30	302.3	85.2
	31	301.8	84.2
13	32	301.4	72.1
	33	303.8	74.1
14	34	305.0	73.0
	35	302.8	80.5
	42[a]	304.9	74.1
	43[a]	304.8	69.8
15	36	306.5	70.4
	37	303.7	65.8
	38	313.6	70.7
	39	310.2	71.7
16	44	307.3	68.2
	45	303.3	68.1
17	46	303.1	68.5
	47	301.4	74.8
18	48	304.3	82.5
	49	302.3	76.5
	54[a]	298.1	71.5
19	50	296.1	59.7
	51	307.0	80.0
	52	311.1	66.5
	53	309.0	64.0
20	78	307.0	77.1
	79	300.4	64.4
21	81	311.5	72.3
	82	294.3	63.0

[a] Erasure in machine direction with specimen oriented 180° to that of the other specimens (i.e., in the antiparallel direction).

ploratory phase of the work we have covered thus far. However, in the standardization of a testing procedure involving the erasability of papers, the characteristics and behavior of the abrading medium are important and, therefore, were made the objective of this phase of the investigation. The following section presents the work covered to date in our study of one abrading medium—namely, the "Calibrase" abrading wheels, type CS17F, manufactured by the Taber Instrument Co. Twenty-one wheels obtained in three different shipments from the manufacturer are represented in

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4.	35/65	350	350-35NS	Continuous, clear to slightly hazy film. Tough and flexible with no tack. Base for water. Paints and paper coatings.
5.	40/60	350-S	350-N	Continuous, clear to slightly hazy film. Tough and flexible with slight tack. Paint, paper, leather and textile coatings.
6.	50/50	417-50RS	417-50NS	Continuous clear film. Tough and flexible with slight tack.
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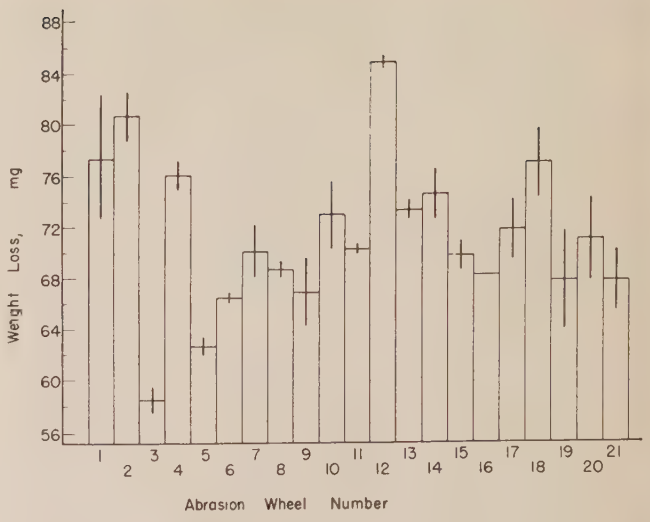

Fig. 1. Comparison of the average weights of material removed by abrasion of sample 24 with 21 different abrading wheels

this study; these wheels were dated Dec. 15, 1947; Jan. 6, 1948; and March 30, 1948.

Procedure

To determine the degree of uniformity and reproducibility of the different wheels, their abrading action on a sample of bond paper was studied. Physical tests were made on the test specimens of the paper before and after abrasion so that a comparison could be made of the results obtained with the different wheels. Sample 24, a 20-pound bond paper having a rag content of 50%, was used for this study. This paper was obtained in the form of a small roll which enabled selection of the test specimens for erasure from a narrow strip along the machine direction of the paper. Obtaining the specimens in this manner would tend to minimize the effects of sample variation. The physical properties evaluated for checking the uniformity of the abrading action were weight, gloss, and reflectance (R_∞ and R_0). All the erasures and the physical tests that would be affected by temperature and relative humidity were made in a room conditioned at 50% relative humidity and 75°F.

After conditioning the sample of bond paper in the atmosphere of the humidity room, two parallel lines spaced 1.5 inches apart were ruled in the machine direction on the felt side of the specimen with the Schur-Levy ruling pen. As in the previous work, Sanford's Premium Writing Fluid, a permanent blue-black ink was used. Following the application of the ink lines, the specimens were further conditioned in the atmosphere of the humidity room for a minimum period of 24 hours prior to abrasion.

Before abrading the specimens, each wheel was given a wear-in run of about 2000 strokes in order to adapt the wheel to the slight mechanical irregularities of the abrading machine. At least two specimens were then abraded with each wheel, with the erasing stroke parallel with the machine direction of the paper. Each specimen was abraded 216 strokes, which is the number of strokes required to obliterate the ink lines.

Following abrasion, two 2.5-inch squares were cut from each specimen, one from the central portion of the abraded area and the other from the adjacent un-

abraded surface. The physical tests subsequently carried out on these specimens were made in accordance with the testing procedures described earlier in this report.

Results and Discussion

The results of the physical measurements on the specimens abraded with the 21 different abrading wheels are presented in Tables IV, V, and VI and Figs. 1 to 5. In Table IV, the first column presents the number assigned to the abrading wheel, the second, the specimen number, the third, the weight of the specimens (2.5 inches square) before abrasion, and the fourth, the loss in weight of the specimens (2.5 inches square) caused by the erasure. Upon examination of the data presented in this table, it will be observed that the amount of material removed by abrasion with the different wheels varied from a minimum of 57.1 mg. to a maximum of 87.8 mg. for specimens receiving the same number of abrading strokes. A study of the variability of the weights of the unabraded specimens, of the weights of the immediately adjacent abraded specimens, and the variability of the weight losses should reveal the order of magnitude of the variability attributable to the abrading wheels. It should be recalled that the weights tabulated in the third and fourth columns of Table IV are not for the same specimens before and after abrasion, but for immediately adjacent specimens. Hence, there will be a variability in the weight loss (last column) which is attributable to specimen variation. The standard deviation of the weights of the unabraded specimens is the root-mean-square of the deviations of the individual values from the average; calculation shows that this quantity is 4.2 mg. The standard deviation of the weights of the abraded specimens is 7.4 mg. This value is greater because of the variability of the abrading wheels and also the variability of the resistance to erasure of the paper. It is impossible to partition the difference with regard to these latter sources of variability, because a standard deviation is itself subject to considerable uncertainty, and because sufficient data cannot be obtained with a single abrading wheel. It would be expected that the standard deviation of the weight loss (last column) would be greater than that of the weight of the abraded specimens because, in general, the standard deviation of the difference between two independent quantities is equal to the

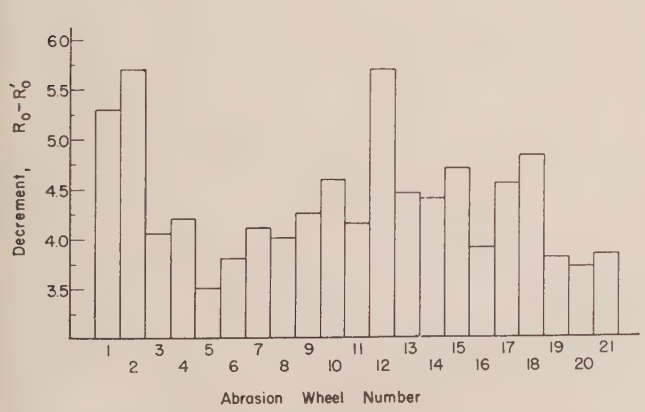

Fig. 2. Comparison of the changes in reflectance (R_0 — R'_0) of sample 24 when abraded with 21 different abrading wheels

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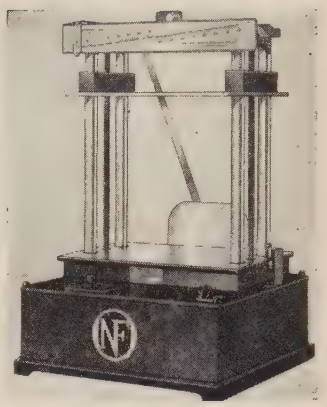

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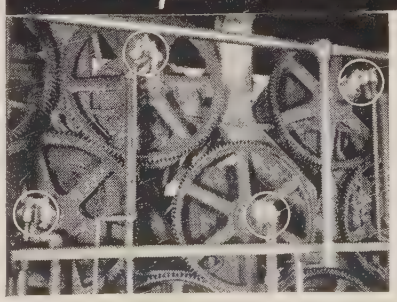

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Table V. Effect of Erasure on Reflectance

Abrasion wheel	Specimen	Erasure in machine direction — Before R_∞	Before R_0	After R'_∞	After R'_0	$R_0 - R'_0$
1	1	78.9	72.0	76.5	66.2	5.8
	2[a]	78.9	71.8	76.0	66.3	5.5
	3	78.8	71.8	76.6	67.1	4.7
2	4[a]	78.9	71.6	75.9	65.6	6.0
	5	78.9	71.9	76.2	65.6	6.3
	6	79.0	72.1	77.2	67.1	5.0
3	7	79.0	71.7	77.2	67.4	4.3
	8	79.0	71.9	77.3	68.1	3.8
4	9	79.0	71.6	77.4	67.1	4.5
	10	79.0	71.3	77.4	67.4	3.9
5	11	79.1	72.2	77.5	68.5	3.7
	12	78.9	71.5	77.4	68.2	3.3
6	13[a]	79.1	71.6	77.2	67.6	4.0
	14	79.0	71.2	77.4	67.6	3.6
	15[a]	79.0	71.6	77.6	67.8	3.8
	16	79.0	71.9	77.7	68.1	3.8
7	17	79.1	71.9	77.5	67.5	4.4
	18	78.9	71.7	77.6	67.1	4.6
	19[a]	79.1	71.4	77.6	67.4	4.0
	20[a]	79.0	71.3	77.3	67.9	3.4
8	21	79.0	71.4	77.6	67.6	3.8
	22	79.0	71.4	77.6	67.2	4.2
9	23	79.0	71.7	76.3	67.7	4.0
	24	79.1	72.0	76.9	67.5	4.5
10	25	79.0	72.0	77.1	67.1	4.9
	26	79.1	71.6	77.2	66.8	4.8
	27	79.0	71.1	77.0	67.2	3.9
	40[a]	78.8	71.4	77.0	66.9	4.5
	41[a]	79.0	71.5	76.8	66.7	4.8
11	28	79.0	71.2	77.3	67.1	4.1
	29	79.0	71.7	77.4	67.5	4.2
12	30	79.0	71.5	77.2	66.0	5.5
	31	79.0	71.5	77.3	65.6	5.9
13	32	79.1	71.4	77.4	67.1	4.3
	33	79.1	71.9	77.4	67.3	4.6
14	34	79.0	71.4	77.4	67.5	3.9
	35	79.0	71.5	77.6	66.4	5.1
	42[a]	78.7	71.4	77.2	66.9	4.5
	43[a]	78.7	71.1	77.1	67.1	4.0
15	36	79.1	71.9	76.9	66.8	5.1
	37	79.0	72.0	77.1	67.7	4.3
	38	79.0	72.3	77.2	68.0	4.3
	39	79.1	72.2	77.2	67.1	5.1
16	44	78.8	71.5	77.1	67.7	3.8
	45	78.8	71.5	77.2	67.5	4.0
17	46	78.8	71.2	77.5	67.4	3.8
	47	78.9	71.6	77.4	66.3	5.3
18	48	78.9	71.6	77.4	66.5	5.1
	49	79.0	71.1	77.4	66.8	4.3
	54[a]	79.1	71.6	77.4	66.5	5.1
19	50	79.0	71.2	77.7	67.4	3.8
	51	78.9	71.3	77.4	67.0	4.3
	52	79.0	72.1	77.7	68.2	3.9
	53	79.0	71.9	77.7	68.7	3.2
20	78	78.9	71.6	77.8	67.7	3.9
	79	78.9	71.2	77.6	67.7	3.5
21	81	79.1	71.9	78.0	67.9	4.0
	82	78.9	71.0	77.8	67.3	3.7

[a] Erasure in machine direction with specimen oriented 180° to that of the other specimens (i.e., in the antiparallel direction).

square root of the sum of the squares of the standard deviations of the two quantities. However, the standard deviation of the weight loss was calculated from the deviations of the individual values from the average and found to be 6.9 mg. Again, it is necessary to recall the uncertainty of the standard deviation. If the abrading wheels were perfectly uniform, and if the resistance of the paper to abrasion had no variability, then the expected standard deviation in the weight loss would be $4.2\sqrt{2} = 5.9$ mg. Thus it may be concluded from this portion of the study that the variability of abrasiveness of the 21 abrading wheels is of the same order of mag-

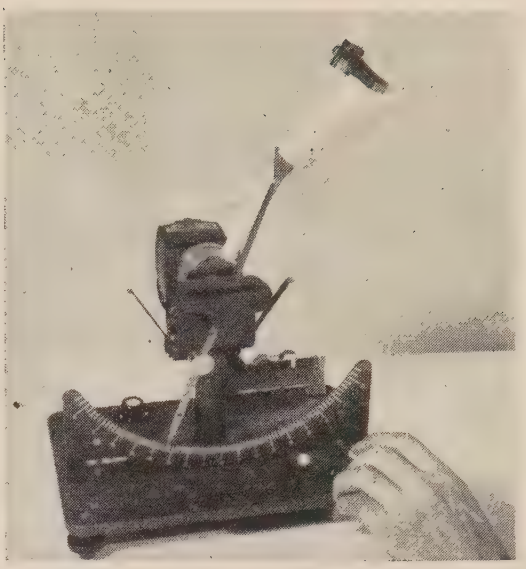
nitude of, or possibly smaller than, the variability of the paper. It should be noted that the paper and the manner of choice of specimens along the same machine direction zone were such that variability of the specimens was small.

The average weight of material removed by abrasion with each wheel is plotted as a function of the wheel number in Fig. 1. The vertical lines at the top of each "chimney" represent the plus and minus values of the standard deviations of the losses. It is impossible to draw conclusions from the latter, because only a few specimens could be abraded with each wheel, so that the

Table VI. Effect of Erasure on Gloss

Abrasion wheel	Specimen	Erasure in machine direction: Before In	Before Across	After In	After Across	Ratio
1	1	13.0	10.8	11.8	7.8	0.82
	2[a]	12.4	10.8	11.3	8.2	0.82
	3	12.1	12.6	14.6	10.6	1.02
2	4[a]	13.6	11.4	13.2	10.3	0.94
	5	12.0	10.3	12.0	8.0	0.90
	6	11.4	10.0	11.6	8.0	0.92
3	7	11.0	10.0	11.4	8.0	0.92
	8	11.4	9.8	12.1	8.8	0.99
4	9	11.2	10.0	12.0	8.2	0.95
	10	11.4	10.1	12.7	8.7	1.00
5	11	11.8	10.0	14.8	9.7	1.12
	12	11.2	10.1	13.8	9.6	1.10
6	13[a]	11.6	10.3	15.2	10.3	1.16
	14	11.0	10.0	13.8	9.4	1.10
	15[a]	11.4	10.0	12.3	9.2	1.00
	16	11.8	10.2	13.1	8.8	1.00
7	17	10.9	9.7	10.9	7.3	0.88
	18	10.4	9.3	11.6	8.0	0.99
	19[a]	11.2	10.0	11.0	8.0	0.90
	20[a]	11.0	9.8	13.9	10.0	1.15
8	21	11.2	9.6	10.6	7.9	0.89
	22	10.7	9.6	14.2	9.5	1.11
9	23	14.2	13.4	19.2	14.0	1.20
	24	14.2	12.9	15.8	12.2	1.03
10	25	14.1	12.8	14.2	11.0	0.94
	26	13.6	12.3	14.2	10.9	0.97
	27	12.6	11.5	14.5	10.3	1.03
	40[a]	14.6	13.3	16.4	12.4	1.03
	41[a]	14.0	13.1	17.8	12.5	1.12
11	28	12.8	11.9	16.2	11.8	1.13
	29	14.0	12.7	16.0	11.6	1.03
12	30	13.6	12.6	14.2	11.0	0.96
	31	14.0	12.8	15.0	11.0	0.97
13	32	14.0	13.0	16.2	11.6	1.03
	33	13.4	12.8	16.1	11.8	1.06
14	34	13.9	12.6	17.4	12.6	1.13
	35	14.6	12.9	16.0	11.5	1.00
	42[a]	14.2	13.0	16.0	11.9	1.02
	43[a]	13.9	12.8	16.1	11.2	1.02
15	36	14.0	13.2	17.2	12.6	1.10
	37	15.0	13.8	17.0	12.5	1.02
	38	14.9	13.2	15.9	12.4	1.01
	39	15.1	13.8	17.4	13.2	1.06
16	44	14.0	13.0	17.0	12.9	1.10
	45	14.0	12.9	16.2	12.1	1.05
17	46	13.8	12.9	16.7	12.2	1.08
	47	11.4	9.9	12.9	8.2	0.99
18	48	10.6	8.9	11.8	7.9	1.01
	49	9.7	8.6	11.2	7.8	1.04
	54[a]	12.0	11.2	13.8	10.3	1.14
19	50	10.6	8.4	14.0	8.5	1.18
	51	10.1	8.7	8.5	6.2	0.78
	52	11.1	9.4	17.9	9.8	1.35
	53	11.3	9.6	13.6	9.0	1.08
20	78	11.2	10.0	12.0	8.2	0.95
	79	11.0	9.4	13.1	8.9	1.08
21	81	10.8	9.8	13.4	8.4	1.01
	82	10.0	8.8	10.8	6.6	0.92

[a] Erasure in machine direction with specimen oriented 180° to that of the other specimens (i.e., in the antiparallel direction).



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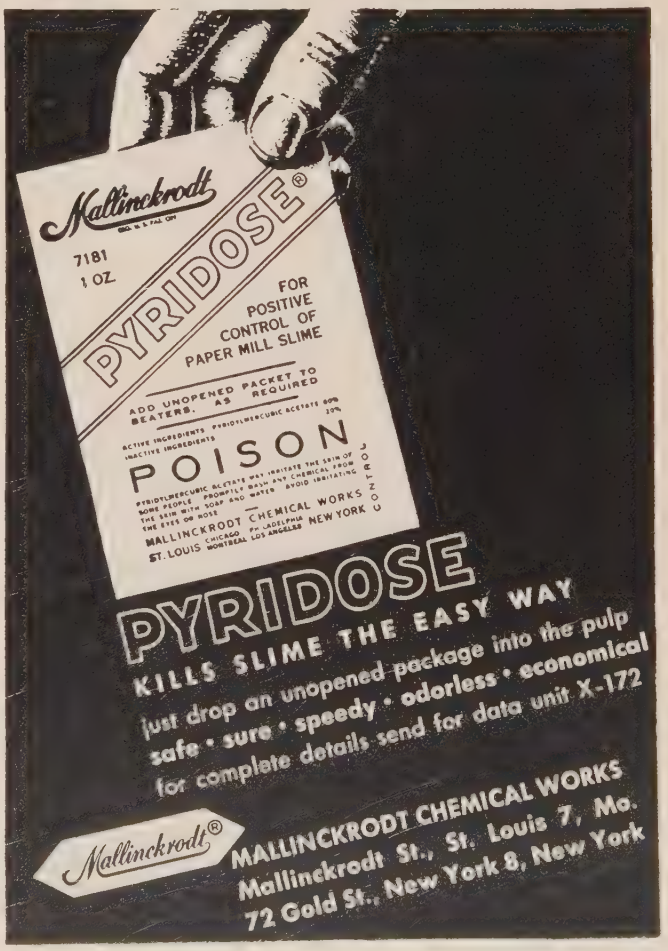
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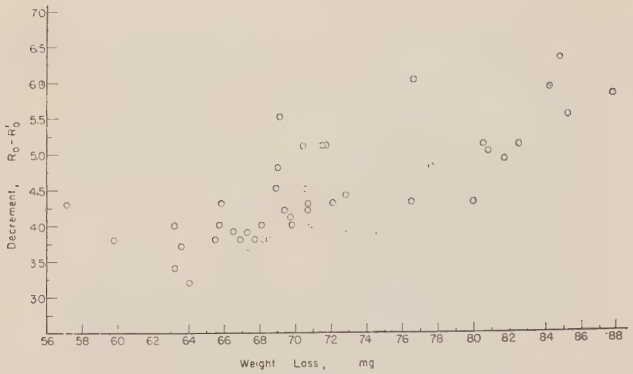

Fig. 3. Comparison of the changes in reflectance ($R_0 - R'_0$) with the weight of material removed by abrasion of sample 24

standard deviations are subject to considerable uncertainty.

Our early work showed that there was no correlation between caliper change and the amount of material removed by abrasion. This was again confirmed by a series of caliper measurements that were made on the first 20 specimens of Table IV. A plot of the amount of material removed by abrasion as a function of the original weight of the specimen also failed to show any correlation.

The reflectivity data for the reproducibility study (obtained with the G.E. recording spectrophotometer at a wavelength of 555 mmu) are presented in Table V. A chart showing the average difference in reflectance ($R_0 - R'_0$) plotted as a function of the wheel number is presented in Fig. 2. Upon examination of the individual values in the table, it will be observed that the differences in reflectance ($R_0 - R'_0$) varied from a minimum of 3.2% for wheel 19 to a maximum of 6.3% for wheel 2, with an average value of 4.4%. The correlation between the amount of material removed and the difference in reflectance ($R_0 - R'_0$) may be seen by referring to Fig. 3. The decrement in R_0 is seen to increase generally with the weight increment, but an accurate relationship between the two quantities is absent.

The results obtained with the special low angle glossmeter for the abraded and unabraded specimens are presented in Table VI. Here, as in the earlier work, the ratio was calculated by dividing the average values for the abraded portion of the specimen by the average values for the unabraded surface. Relatively large variations in the gloss were produced as will be apparent by referring to Fig. 4, which presents the gloss ratio as a function of the wheel number. The variations observed in the results obtained with a single wheel are also large. Wheel 19 shows the greatest irregularity, producing both the maximum and minimum values in the gloss ratio. If the data for wheel 19 be disregarded, the range of variation in gloss for the different wheels is reduced to about 40%.

In plotting the gloss ratios as a function of the amount of material removed by erasure (Fig. 5), it will be observed that the gloss ratio decreases as the weight decrement increases. In general, it was observed that the erased surface becomes more irregular and scuffed as the abrasion proceeds into the sheet.

OBSERVATIONS AND COMMENTS ON THE ABRASION WHEELS

During the course of the reproducibility study, each wheel was carefully examined prior to installation in the abrading machine to determine if any irregularities could be detected by either a visual inspection with the aid of a magnifier, or by the sense of touch. The wheels were also inspected at various time intervals during erasure for any changes in appearance which might account for the observed variations in the physical test data for the abraded specimens. These examinations revealed that two wheels (20 and 21), obtained in a single lot dated March 30, 1948, wore down more rapidly than the wheels obtained in the other two shipments; furthermore, it was also observed that wheels 20 and 21 produced the most uniformly abraded surfaces. (This is in accord with the observations reported in Part II of this report.) The specimens abraded with the remaining wheels (1 to 19) showed an irregular abrasion.

Careful visual inspection of the wheels during abrasion failed to show any difference in the condition of the portion of the wheel which had just rubbed against the specimen for a complete erasing stroke. During abrasion, the surface of the entire wheel is covered with a fine dust from the paper which the fan fails to remove, but the particles in the wheel, which presumably do the abrading, do not appear to be restricted by this fine powder. The slightly heavier abraded area at the end of the erasing stroke suggests that the exaggerated abrasion at the beginning and the end of the stroke may be accounted for, in part, by the real difference between the starting and sliding coefficients of friction between the paper and the wheel. Although the back stroke of the abrading machine is the non-erasing stroke, the wheel apparently abrades slightly as it starts from rest for the return stroke.

EFFECT OF ERASURE PARALLEL AND ANTIPARALLEL TO THE MACHINE DIRECTION

An interesting phenomenon concerning a pronounced directional effect was observed while abrading the specimens that were used to obtain the data presented in Tables IV, V, and VI. These specimens were all abraded with the direction of the abrading stroke parallel with the machine direction of the paper. It was found to be insufficient merely to have the erasing stroke parallel to the machine direction, for it was discovered that orienting the specimens through an angle of 180° or abrading them in the antiparallel direction (as

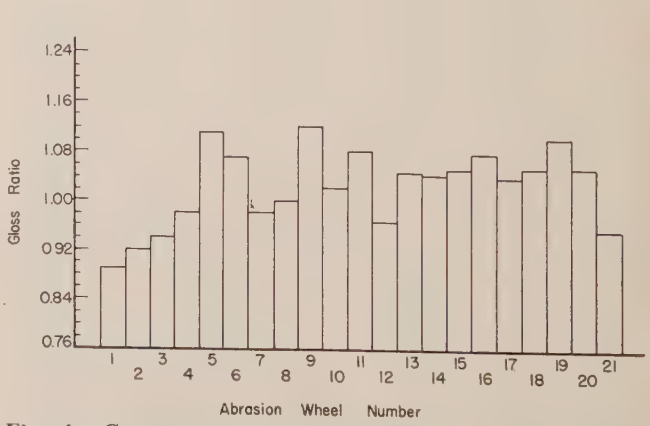

Fig. 4. Comparison of the gloss ratios obtained when sample 24 was abraded with 21 different abrading wheels

judged with respect to the water mark) resulted in a marked difference in the appearance of the abraded surfaces. The surfaces of the specimens abraded in the normal manner, with the water mark of the paper oriented in a standard way, were smooth, uniform, and relatively free of irregularities. When the specimens were abraded in the antiparallel direction, however, the abraded surfaces were irregularly scuffed and contained bundles of fibers that had been pulled loose, thus leaving pits and tufts of fuzz. The specimens that were abraded in the antiparallel direction are marked with an asterisk in Table IV. A comparison of the weight, gloss, and reflectance data presented in Tables IV, V, and VI shows no apparent significant differences in the results obtained for the specimens abraded in the parallel and the antiparallel directions. A slight trend toward a smaller weight removal for a given number of strokes might exist for the abrasions made in the antiparallel direction, but insofar as the gloss and reflectance values are concerned, no detectable trends are observed; the latter fall both above and below the mean values observed for the entire group of specimens. It is apparently impossible to detect the directional effects through the physical tests that have been made thus far. This effect was most easily detected by viewing the abraded specimens with transmitted light.

In order to determine whether the pronounced directional effects (observed for sample 24) were inherent in other papers, fourteen different papers—namely, samples 13 to 19, 21 to 24, and 28 to 30, inclusive, were abraded parallel to the machine and antimachine directions. [These samples are described in Part II (*2*) and in Table I of this report.] Of these, nine papers displayed a marked directional effect, two showed no effect at all, and three were classed as doubtful.

SLIDING FRICTION TEST

The directional effects manifest when a sheet of paper is reversed in the abrading machine might be explained on the basis of a "shingled" effect of the fibers in the sheet. If such were the case, the abrading wheel would slide over the tops of the protruding fibers in one direction, whereas, in the opposite direction, the wheels would worry the fibers and cause the scuffing and irregularities observed for the antiparallel erasures.

To determine if the "shingled" effect was large enough to cause a real difference in the coefficients of sliding friction for various orientations of the paper, attempts were made to measure the sliding friction of several different papers (samples 3, 16, 19, 24, and 29) by means of an inclined plane. The inclined plane in this case consisted of a piece of plate glass upon which a specimen of the sample to be tested was placed. Another specimen of the same sample was then attached to one surface of a smooth wooden block which, in turn, was placed over the first specimen at the top of the incline. The plane was then elevated slowly until the block slid down the incline at a uniform rate. The sliding was started by a very gentle tapping of the wooden block containing the second specimen. The papers were tested for the four possible orientations of the fibers with the felt sides opposed. The tangent of the angle of tilt at which the block slid down the incline at a uniform rate was measured and used as the coefficient of sliding friction.

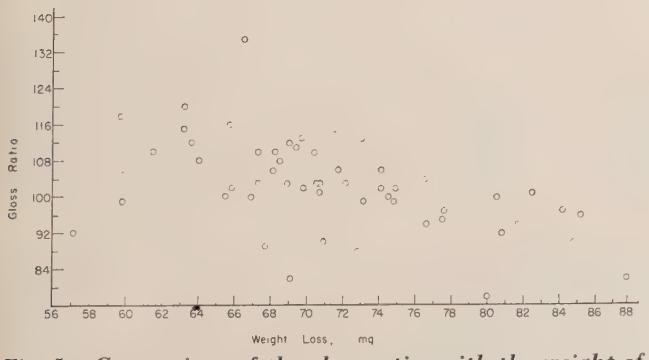

Fig. 5. Comparison of the gloss ratios with the weight of material removed by abrasion of sample 24

For the measurements made in the foregoing manner, all the samples but sample 24 showed either a very small difference in angle for the four orientations, or the differences were random. For the first trial tests using sample 24 (the sample exhibiting the most pronounced directional effect) real and reproducible differences seemed to exist between the various relative orientations of the paper; however, later measurements, using a greater number of specimens, failed to show that real differences existed.

ABRADING RATES

In order to obtain more detailed information concerning the manner in which material is removed during the erasing process, a study was made of the abrading rate as the erasure proceeded from the surface into the body of the sheet—i.e., the weight loss was obtained as a function of the number of abrading strokes. The samples selected for this study were three papers having widely different erasing characteristics. These were: sample 3, a paper that developed a polished surface during erasure, having a gloss ratio of 3.0; sample 23 which was roughened by erasure, having a gloss ratio 0.3; and sample 24 which had a gloss ratio of about one.

For this study the specimens were cut to approximately 6 by 10 inches and the whole sheet was weighed after each abrading interval to determine the weight loss. The size of the surface abraded was about 3 by 3 inches. The specimens for samples 23 and 24 were weighed after each 100-stroke abrading interval until they were abraded for a total number of strokes ranging from 1400 to 1900 strokes. The specimens for sample 3 were weighed after each 300-stroke interval until they were abraded for a total of 6600 strokes. These samples were abraded at the following atmospheric conditions: samples 3 and 24 at 50% R. H. and 75°F.; sample 23 at 55% R. H. and 75°F.; and samples 23 and 24 at 65% R. H. and 75°F., and at 85% R. H. and 78°F.

In the initial phase of the study on abrading rates, it was observed that a time delay in weighing the specimens after the 100 and 300-stroke abrading intervals introduced variations in the weight decrements which were of about the same order of magnitude as the weight decrements themselves. When the specimens were weighed immediately after each abrading interval, the weight loss values obtained for successive abrading intervals were in good agreement—i.e., the rate of change in weight for successive intervals was uniform. If, however, the weighing of the specimens was delayed

or the weighings were made at various time intervals following an abrading interval, the weight of the specimen increased as a function of time by values ranging up to about 3 mg.

The foregoing observations would tend to indicate that the moisture content of the specimen was reduced during the erasing process. In order to check this possibility, unabraded specimens were exposed to atmospheric conditions which were the same as those obtained for the test specimens and then weighed when the weighings were made for the abraded specimens. Some of the control specimens were merely exposed to the atmosphere of the room, whereas others were supported in the air stream of the fan; the temperature of the air passing through the fan was raised about 0.2° to 0.4°C., thus causing a slight lowering of the relative humidity. The results obtained in these measurements indicated that neither the small fluctuations in the relative humidity of the room nor the slightly heated air from the fan accounted for the variations in the weight loss values obtained for the abraded specimens. It appeared, therefore, that sufficient heat was generated in the abrading process to lower the moisture content of the specimen by a measurable amount.

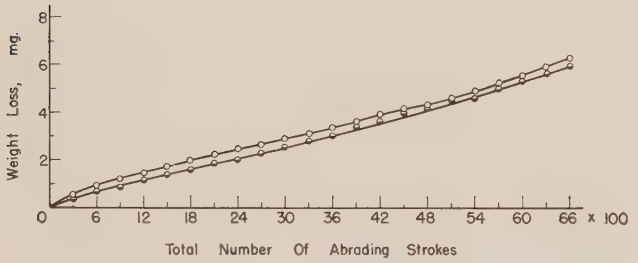

Fig. 6. Comparison of the weight of material removed from sample 3 by abrasion of surface about 3 by 3 inches, with total number of abrading strokes over the whole erased area

In order to minimize the variability of the weight loss data caused by the apparent change in the moisture content, all the specimens used for this study of the abrading rates were weighed immediately after each abrading interval (this was done for only this portion of the work). The results obtained in this manner for samples 3, 23, and 24 are presented in Figs. 6 to 8, respectively. Upon examination of the curves in these figures, differences in the abrading characteristics and rates will be observed for the three samples. The curves for samples 23 and 24 exhibit approximately the same characteristics, and it is seen that the abrading rate for these papers increased as the erasure proceeded from the surface into the body of the sheet. The curve for sample 3, however, indicates that the abrading rate for this paper remains relatively constant. It will be recalled that sample 3 is a paper that developed a polished surface having a high gloss ratio.

In general, it will be observed that the abrading rate increased as a function of the relative humidity. The reasons for the inversion of the curves for sample 23 which were obtained at relative humidities of 55% and 65% are not definitely known. It should be noted that abrasion wheels 9 and 12 were used for obtaining the data at the relative humidity of 55% and that wheel 6 was used at the relative humidity of 65%. It is possible, therefore, that wheel and specimen variations alone, or a combination of both, contributed to the observed anomaly.

EFFECT OF SPEED OF ABRADING STROKE ON ERASURE

The abrasions that have been made thus far in this

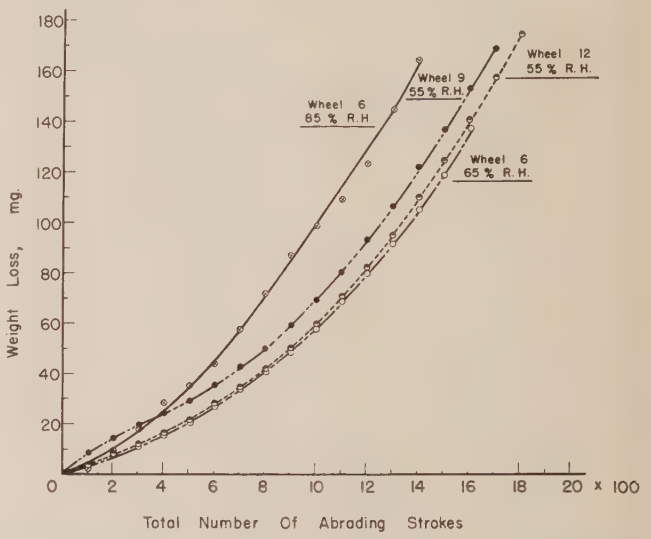

Fig. 7. Comparison of the weight of material removed from sample 23 by abrasion of surface about 3 by 3 inches, with total number of abrading strokes over the whole erased area

study have all been made with the abrading machine adjusted to abrade at a rate of 72 erasing strokes per minute. In order to determine the manner in which the speed of the erasing stroke would affect the erasing

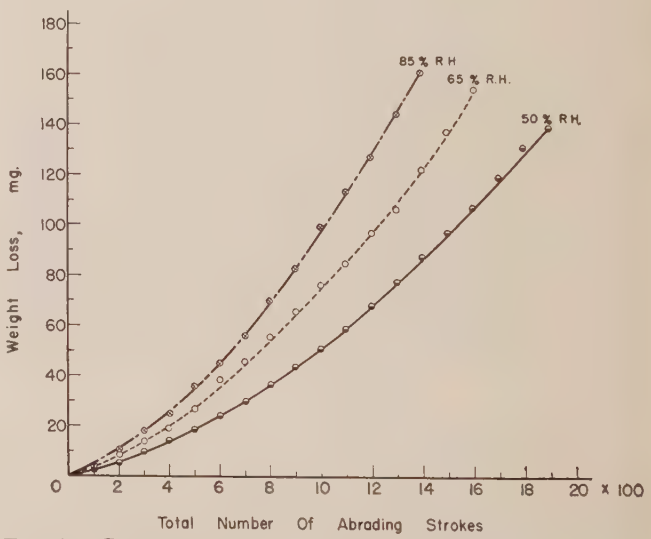

Fig. 8. Comparison of the weight of material removed from sample 24 by abrasion of surface about 3 by 3 inches, with total number of abrading strokes over the whole erased area

characteristics of paper, a series of erasures were performed on specimens of sample 24 using speeds of 36, 72, and 144 erasing strokes per minute. Because of excessive vibration of the abrading machine, higher available stroke speeds were not used in this study.

The procedures employed for abrading the specimens and obtaining the physical test data were the same as those used for the reproducibility study of the abrading wheels described earlier in this report. All the specimens were abraded with same number of strokes (216 strokes over any given point in the erased area). The results, showing the effects of abrading speed on weight removal, gloss, and reflectance ($R_0 - R'_0$), are presented in Table VII.

Table VII. Effect of Speed of Abrading Stroke on Erasure

216 Strokes over Any Given Point in the Erased Area

	Number of strokes per minute		
	36	*72*	*144*
Weight loss, mg.	72.4	71.3	53.9
Gloss ratio	1.0	1.0	1.4
Reflectance ($R_0 - R'_0$)	5.0	4.4	3.8

From the data in Table VII it will be seen that the amount of material removed at the highest speed is considerably less than that removed at the two lower abrading speeds. It seems likely that the lowered weight loss at the higher speed of erasure is attributable to reduced moisture content caused by heating. The reflectivity data ($R_0 - R'_0$) show a similar trend, since the values decreased as the number of abrading strokes per minute were increased. The latter show a gradual decrease as a function of the abrading speed, whereas the weight decrements show an abrupt change in going from 72 to 144 strokes per minute. A comparison of the gloss ratios would tend to indicate that the sample developed a slightly polished surface while being abraded at 144 strokes per minute.

EFFECT OF VERTICAL THRUST OF ABRASION WHEEL ON ERASURE

Throughout this study on erasability, the vertical *thrust* of the abrading wheel on the sample in the abrading machine was 555 grams. Since hand erasures are, in all probability, made at *pressures* exceeding the abrading pressures that have been employed thus far, it was believed desirable to determine the effects of increasing the vertical thrust on the abrading wheel. The effects of employing a lighter load (370 grams) have already been investigated for three papers; the results have been reported in Part II (*2*). It will be recalled that the principal difference between erasures performed with vertical thrusts of 370 and 555 grams was that a fewer number of abrading strokes were required to obliterate the ink lines when the specimens were abraded under the greater load. To investigate the effects of increasing the vertical thrust, specimens of samples 3, 23, and 24 were abraded under conditions in which the vertical thrust of the wheel on the paper was 760 and 1000 grams. The specimens were abraded and tested for changes of their physical properties in accordance with the procedures employed to obtain the data presented in Tables I, II, and III. Each specimen was abraded with the number of strokes required to expunge a pair of ink lines which were ruled on the specimens in accordance with the procedures described earlier in this report. The results obtained for the samples abraded in the foregoing manner are presented in Table VIII.

The data presented in Table VIII show that the number of abrading strokes required to obliterate the ink lines is reduced considerably when the vertical thrust of the abrading wheel is increased from 555 to 1000 grams. Based on the average number of strokes at a load of 555 grams the number of strokes were reduced to about 66 and 50%, respectively, for specimens abraded under loads of 760 and 1000 grams. It is of interest to note that the number of strokes required to remove the ink lines is roughly inversely proportioned to the thrust. Except for the weight loss values for sample 3, no definite trends are observed which would indicate that the vertical thrust of the abrading wheel on the specimen would seriously affect the erasure results for a paper.

Table VIII. Effect of Vertical Thrust of Abrasion Wheel on Erasure

Erasure in Machine Direction

Sample	*Load*	*Strokes*[a]	*Weight loss, mg.*	*Gloss ratio*	*Reflectance* ($R_0 - R'_0$)
3	555	1350	57.6	3.3	11.2
3	760	925	62.3	3.4	9.5
3	1000	705	81.7	2.6	10.5
23	555	245	63.9	0.4	4.1
23	760	163	59.9	0.4	3.6
23	1000	117	71.7	0.4	3.3
24	555	216	71.3	1.0	4.4
24	760	146	68.4	1.1	4.2
24	1000	111	70.6	1.2	3.9

[a] This is the number of strokes over any given point in the erased area (not the total number of strokes over the whole area).

The vertical thrust of 1000 grams is about the maximum practical load that could be used for the abrasion of lightweight papers, particularly when relatively large surfaces are being abraded. The increased drag of the wheel on the paper is sufficient to tear the specimens after they have been weakened by abrasion. Another serious objection to the use of a load as high as 1000 grams is that the wheels develop flat spots which would alter the conditions of abrasion.

REPEATED ERASURES

Erasability data were obtained for a series of samples which had been written upon and erased for a second time. Specimens containing a pair of ink lines were abraded for the number of strokes required to expunge the ink lines, then written upon again by applying a second pair of ink lines and subsequently abraded a second time for the number of strokes required to obliterate the second pair of lines. The methods for applying the ink lines and abrading the specimens were as earlier described. The papers employed for this study were samples 3, 23, 24, 26, and 27; the results obtained for these papers, giving the number of abrading strokes required to obliterate the ink lines for the first and second erasures, are presented in Table IX. The last column in this table gives the ratio obtained by dividing the number of strokes for the second erasure by the number of strokes for the first erasure. These data were obtained under atmospheric conditions of 65% R. H. and 76°F.

Examination of the data presented in Table IX reveals that fewer strokes are required to remove a pair of ink lines from the surface of a specimen that had al-

ready been abraded than are required to remove the lines from an unabraded surface. The number of strokes required for the second erasure is, for some specimens, less than 50% of the number required for the first erasures. These data tend to show that any possibility of greater penetrability of ink in the abraded specimens (requiring a larger number of strokes to remove the ink) is apparently counteracted by the higher

Table IX. Data on Repeated Erasures

Erasure in Machine Direction

Sample	Number of strokes[a]		Ratio, %
	First erasure	Second erasure	
3	1200	825	69
3	1200	825[b]	69[b]
23	210	108	51
23	225	128	57
24	210	144	69
24	195	124	64
26	825	420[b]	51[b]
26	900	405[b]	45[b]
27	855	420	49
27	870	435[b]	50[b]

[a] Number of strokes over any given point in the erased area (not the total number of strokes over the whole area).
[b] These specimens tore before the desired end point was reached for the second erasures; thus, the number of strokes reported are slightly low.

abrading rates in the body of the paper. However, sample 3 is a paper for which the abrading rate remained relatively constant as the erasure proceeded from the surface into the body of the sheet (see Fig. 6), yet the number of strokes for the second erasure are lower than the first by about 31%. This would seem to indicate that the penetration of the ink in the abraded specimens was less than that in the unabraded specimens. The abrading rates for samples 23 and 24 were earlier found to increase as the erasure proceeded into the body of the sheet (see Figs. 7 and 8); thus, the relatively large reduction for the second erasures would be expected on the basis of increased abrading rates.

EFFECT ON ERASURE OF USING INKS OF DIFFERENT COMPOSITIONS

To determine the effects of employing inks of different compositions, a series of specimens of samples 3, 23, and 24 were abraded after they had been written upon with three different inks—namely, Sanford's Premium Writing Fluid (an acid ink which was used extensively throughout this study), Parker's Superchrome (an alkaline ink), and Higgin's American India Ink (an alkaline and waterproof black drawing ink). Attempts were also made to use a fourth ink, Remington Rand's black duplicator ink; however, because of the low fluidity of this ink, transfer difficulties were encountered in applying the ink to the paper with the Schur-Levy rotary pen. The specimens were abraded and tested for changes in their physical properties in accordance with the procedures described earlier in this report. Each specimen was abraded for the number of strokes required to obliterate the ink lines. The data obtained in the foregoing manner are presented in Table X.

Examination of the data presented in Table X reveals that there are no general trends in the erasability results obtained with the three different inks. Significant differences, if they exist, seem to be over shadowed by specimen variations. The results for ink B and samples 3 and 24 seem to be in accord in one respect—i.e., the number of strokes and the corresponding weight loss values are higher than those observed for the other inks and specimens. This suggests that the penetration of ink B might possibly be a little greater than that of the other inks.

EFFECT OF HUMIDITY ON ERASURE

In order to determine the effect of humidity on the erasing characteristics of paper, a series of specimens of samples 3, 23, and 24 were abraded at relative humidities of 50, 65, and 85% and subsequently tested to evaluate the changes in their physical properties. Each specimen was abraded for the number of strokes required to remove the ink lines.

As a second phase of this study, the effect on erasure of applying the ink lines at the different atmospheric conditions was also investigated. In addition to the normal procedure of applying the lines and abrading the specimens at a relative humidity of 50%, specimens ruled at 50 and 65% R. H. were abraded at 65% R. H. and specimens ruled at 50, 65, and 85% R. H. were abraded at 85% R. H.

As a third phase of this study on humidity effects, hysteresis effects were investigated. A series of specimens of samples 23 and 24 were successively conditioned until they were in equilibrium with relative humidities of 50, 30, 85, 30, and 55% and then abraded under the last condition.

Table X. Influence of Inks of Different Compositions on Erasability

Erasure in Machine Direction

Sample	Ink	Strokes[a]	Weight loss, mg.	Gloss ratio	Reflectance $R_0 - R'_0$
3	A	1353	84.9	2.6	10.6
3	B	1440	103.1	2.2	12.6
3	C	1350	57.6	3.3	11.2
23	A	257	99.6	0.3	4.9
23	B	257	91.1	0.3	5.0
23	C	245	63.9	0.4	4.1
24	A	238	97.4	0.9	6.7
24	B	267	97.7	0.9	6.7
24	C	216	71.3	1.0	4.4

[a] Number of strokes over any given point in the erased area (not the total number of strokes over the whole area).
A. Parker's Superchrome Ink, blue-black. B. Higgin's American India Ink, black. C. Sanford's Premium Writing Fluid, blue-black.

The erasability results obtained in the foregoing manner are presented in Table XI, in which the first column designates the sample number; the second, the relative humidity at which the specimens were abraded; the third, the relative humidity at which the ink lines were ruled on the specimens; the fourth, the number of strokes required to remove the ink lines; the fifth, the stroke ratio in per cent obtained by dividing the number of strokes required at the various conditions by the number of strokes required to obliterate the lines on the specimens inked and abraded at a relative humidity of 50%; the sixth, the amount of material removed by erasure for specimens $2^1/_2$ by $2^1/_2$ inches; and the seventh and eighth, the gloss ratio and the reflectance ($R_0 - R'_0$) which were obtained in accordance with the methods described earlier in this report.

Upon examination of the data presented in Table XI it is observed that the abrading rate increases as a function of the relative humidity or, in other words, the number of strokes required to remove the ink lines decreases as the relative humidity is increased. As indicated by the stroke ratios, at a relative humidity of 65%, the number of strokes required to remove the lines from the surface of sample 3 decreased by about 11%; the strokes for samples 23 and 24 decreased by about 13%. At a relative humidity of 85%, the number of strokes for samples 3, 23, and 24 showed decreases of 32, 27, and 31%, respectively. The amount of material that had to be removed to expunge the ink lines at the various humidity conditions remained relatively constant (within the limits of specimen variation). This is substantiated by the reflectance values ($R_0 - R'_0$) which exhibit relatively small variations. The weight and reflectance values would tend to indicate that the penetrability of the papers to ink at the three different relative humidities was substantially the same. The gloss ratios for samples 3 and 24 are observed to increase at the higher relative humidities, which is indicative of the fact that the specimens developed a more highly polished surface. Although not reflected in the gloss ratio, sample 23 showed a considerable amount of "scuffing" when abraded at 65% R. H.; this effect was observed to increase at 85% R. H. The surfaces abraded at 85% appeared rougher than those abraded at the lower humidities; although small bundles of fibers were partially torn from the surface, the areas between the disrupted spots appeared polished. A slightly greater degree of discoloration was also observed at the higher humidity for some of the specimens.

A surprising and interesting phenomenon of erasability is observed when a comparison is made of the number of strokes required to remove the ink lines that were ruled on the specimens at the three different relative humidities and abraded at a relative humidity of 85%. These data indicate that the number of strokes decreases as the relative humidity at which the ink lines are applied is increased. Based on the number of strokes required to remove the lines on the specimens inked and abraded at 50% R. H., it will be observed that the reduction in number of strokes for the specimens having had the lines applied at relative humidities of 50, 65, and 85% is 27, 30, and 35%, respectively, for sample 23; for sample 24, the corresponding reduction in strokes is 31, 38, and 43%, respectively. These results, it would appear, oppose common expectations. For the specimens inked at 85% R. H., it would seem that the conditions are such as to favor a greater penetrability of the paper; evaporation losses should be less, the ink should dry at a slower rate, and the absorbency of the paper might possibly be expected to be greater. However, the weight loss values tend to show that the depth of penetration of the ink was not significantly different for the specimens inked at the three different relative humidities.

In a further analysis of this observed anomaly, the age of the ink lines applied to the specimens at the different humidity conditions was also taken into consideration. The ages of the ink lines at the time of abrasion for the lines applied at relative humidities of 50, 65, and 85% were 16, 5 to 7, and 0.5 to 1 day, respectively. Since the age of the ink line seems to correlate with the corresponding stroke decrements, it would appear offhand that the time of application of the ink plays an important part in the number of strokes required to subsequently expunge the lines; however, observations made throughout this investigation lead us strongly to believe that the age of line has no effect on the number of strokes required to obliterate the lines. Specimens abraded at 50% R. H., having lines varying in age from 10 minutes to 32 days at the time of abrasion, indicated that there were no definite age effects. As a possible explanation for the apparent dependence of the number of abrading strokes on the inking conditions, it is suggested that wetting the specimens with

Table XI. Effect of Relative Humidity on Erasure

Erasure in Machine Direction

Sample	*Abraded at R. H., %*	*Lines ruled at R. H., %*	*Strokes*[a]	*Stroke ratio*	*Weight loss, mg.*	*Gloss ratio*	*Reflectance* $R_0 - R'_0$
3	50	50	1350	100	57.6	3.3	11.2
3	65	50	1200	89	64.9	3.6	11.1
3	65	65	1200	89	65.5	4.6	9.7
3	85	50	910	68	63.4	4.7	8.8
3	85	65	900	67	57.6	4.3	7.5
23	50	50	245	100	63.9	0.4	4.1
23	65	50	214	87	65.5	0.4	3.7
23	65	65	207	84	69.6	0.4	3.4
23	85	50	180	73	70.6	0.6	4.3
23	85	65	171	70	66.8	0.6	4.3
23	85	85	158	65	71.2	0.6	4.4
23[b]	55		228	93	77.9	0.5	4.4
24	50	50	216	100	71.3	1.0	4.4
24	65	50	189	87	70.4	1.1	4.6
24	65	65	194	90	69.6	1.2	4.8
24	85	50	149	69	57.4	1.7	4.7
24	85	65	134	62	65.2	1.7	5.0
24	85	85	124	57	49.2	1.6	4.0
24[b]	55	..	204	94	66.2	1.1	4.7

[a] Number of strokes over any given point in the erased area (not the total number of strokes).
[b] These specimens were preconditioned at relative humidities of 50, 30, 85, and 30%, respectively, and then conditioned and abraded at 55% R. H.

the ink at the higher humidities may have a detrimental effect on the fiber bonds, thus weakening the sheet sufficiently to permit removal of the lines with a fewer number of strokes.

The results obtained for the specimens preconditioned at relative humidities of 50, 30, 85, and 30% show that the previous history of the paper insofar as the relative humidity conditions are concerned does not measurably influence the erasability. The slight decrease observed for the number of strokes is attributed to the fact that the specimens were abraded after the preconditioning cycle at a relative humidity of 55% instead of 50%.

The specimens abraded at the higher relative humidities were more uniformly abraded than those at a relative humidity of 50%—i.e., the exaggerated abrasion formerly observed for the fore part of the stroke on the specimens abraded at 50% R. H. was reduced appreciably when the specimens were abraded at 85% R. H. Since it was also observed that the abrasion wheels wore down more rapidly at 85% R. H., the improvement in uniformity of abrasion is attributed to the increased rate of wear of the wheels. This is in accord with the observations described earlier in this report, where it was observed that the wheels showing the greatest amount of wear produced the most uniformly abraded surfaces.

SUMMARY AND DISCUSSION

The erasing characteristics of 29 different papers have been studied thus far (this includes the papers and work described in Part II). These studies and those of the subsequent investigation of the various phenomena of erasure form the basis for the comments listed below:

1. The number of abrading strokes required to remove ink lines from the different papers varied from about 60 to 1500 strokes. The broad range in number of strokes suggests the possibility that the number of abrading strokes required to expunge written characters would be a satisfactory basis for judging the *ease* of erasure.

2. The amount of material removed by abrasion (i.e., the amount necessary to expunge the lines) varied between 51.7 and 117 mg. (for specimens 2.5 by 2.5 inches); for 23 of the 29 papers, the values fell within a 30-mg. range (60 to 90 mg.). This is a surprisingly small range and is suggestive of the possibility that the depth of penetration of the ink into the various papers does not cover a wide range. Furthermore, it also suggests the inadvisability of using weight loss values as an indirect means for judging the erasing quality of paper.

3. Erasure had an adverse effect on the reflectivity, R_∞, of most papers employed in this study. Decreases in R_∞ varied from a minimum of 0.7% to a maximum of 12.1%. Such changes are large when it is considered that the eye is capable of distinguishing differences of the order of 0.5 to 2.0%. It would seem, therefore, that a comparison of the reflectivities of the abraded and unabraded surfaces of a paper is an important aspect to consider in judging the erasing quality of the paper.

4. The change in the opacity of the paper, as measured by difference in reflectance, R_0, for the abraded and unabraded surfaces, varied between 0.5 and 14.1%. Many of the papers used in this study exhibited changes in opacity which were greater than the minimum change the eye is capable of detecting. This would suggest the importance of opacity measurement in the evaluation of the erasing quality of a paper.

5. Pronounced effects on the special low-angle gloss of the paper were produced by erasure. Eighteen of the 29 papers were "scuffed" during erasure (as shown by the gloss ratios) and the remaining 11 papers either changed very little or developed a polished surface. Although all of the changes in the characteristics of the surface (such as the removal of cockle) are not detected by measuring the low-angle gloss, the values obtained with this instrument are of significance in the evaluation of the degree of fuzziness or gloss developed during erasure.

6. An investigation of the abrading characteristics of 21 different abrading wheels (all type CS17F, Taber Instrument Co.) indicated that the variability of the abrasiveness of the wheels was of the same order of magnitude of, or possibly smaller than, the variability of the paper employed in this study. Although not shown in the erasability data, it was observed that two wheels, obtained in a single lot, wore down more rapidly than the others and produced the most uniformly abraded surfaces. The wheels exhibiting the greater durability abraded more heavily on the earliest part of the stroke. If the control over the manufacture of this type of wheel is such that the characteristics of their abrading action would always fall within the limits exhibited by the 21 wheels investigated, the Calibrase wheels might be considered as a satisfactory abrading medium in a standardized erasure test method. However, in view of the fact that the base material used in these wheels is rubber, aging studies should be made to determine their useful life.

7. Strong directional effects were exhibited by some papers when the abrading strokes were made in directions parallel and antiparallel to the machine direction of the paper. Uniform abrasions were obtained in one direction, whereas irregular abrasions were obtained when the paper was oriented through an angle of 180°. This phenomenon is attributed to a "shingled" effect of the fibers in the sheet.

8. A study of the abrading rates for three papers having widely different erasing characteristics showed that the rate increased as the erasure proceeded from the surface into the body of the sheet for two papers, whereas for the third paper (which developed a polished surface), the abrading rate remained relatively constant.

9. The speed of the abrading stroke seemed to have a small effect on erasability results. The data indicated that the weight loss values and the reflectance ($R_0 - R'_0$) decreased and that the gloss increased slightly with increasing speed of the erasing stroke. The lowered weight loss value at the higher speed of erasure is attributed to a reduced moisture content caused by heating during erasure.

10. The number of abrading strokes required to remove the ink lines was found to be roughly inversely proportional to the vertical thrust of the abrading wheel on paper. The weight loss values for one paper appeared to be influenced by the load on the wheel but no definite trends were otherwise observed which would indicate that the vertical thrust of the abrading wheel would appreciably affect erasability results. If the

number of abrading strokes were eventually used as a means for judging the ease of erasure, standardization of the vertical thrust would be imperative.

11. Erasability data obtained on papers which had been written upon and erased for a second time indicated that the number of strokes required to obliterate the lines ruled on an abraded surface was considerably less than that required to remove the lines from a fresh surface. This would tend to indicate that the penetration of the ink into the paper was greater for the unabraded specimens.

12. The use of inks of different compositions seemed to have no appreciable effect on erasability data. A study involving a greater number of specimens would have to be made before any definite conclusions could be made.

13. Abrasion of papers at relative humidities of 50, 65, and 85% showed that (a) the number of abrading strokes required to remove the ink lines decreased as the relative humidity increased; (b) the amount of material that had to be removed to obliterate the ink lines was essentially the same at the various relative humidities; (c) some papers exhibited a tendency to develop a surface having a slightly higher polish when the relative humidity was increased; (d) the surface of some papers became more highly "scuffed" when the relative humidity was increased; (e) the degree of discoloration of some papers was more pronounced at the higher relative humidities; (f) the number of strokes required to remove ink lines applied at relative humidities of 50, 65, and 85% and abraded at 85% R. H. decreased as the relative humidity at the time of application of the lines increased; (g) based on weight loss values, it appeared that the depth of penetration of the ink at the three different relative humidities was essentially the same; (h) the hysteresis effects were apparently of a small order of magnitude; and (i) the abrading action of the wheels appeared to be influenced by the relative humidity—the wheels wore down more rapidly and more uniform abrasions were obtained at the higher relative humidities.

Although adequately concise definitions of all of the factors relating to erasability have not yet been evolved, the foregoing study has yielded a better understanding of the phenomena of erasure. The results obtained and the observations made throughout these studies emphasize the fact that the three general aspects of the problem with which we are concerned in evaluating the erasing quality of a paper are (a) the function of the paper, (b) the appearance of the erased surface and that of the rewritten characters, and (c) the ease of erasure. These properties, it will be recalled, were discussed in detail in Part I and embrace the chief ideas contained in the definitive statements of erasability obtained from recognized technical personnel of the writing paper industry.

Based on the work which has been carried out thus far, a consideration of these three aspects of the problem with respect to a laboratory procedure for the evaluation of erasing quality would lead to the following discussion.

Of the three properties mentioned above, ease of erasure might be measured most easily. Since the spread in number of strokes for the different papers was quite large, it appears at this time that the number of strokes required to expunge written characters from the paper would be a satisfactory means for evaluating the ease of erasure. By the control of four variables—namely, the uniformity of the abrading wheel, the vertical thrust of the wheel on the paper, the relative humidity, and the method of application of the written characters—it is believed that reliable and reproducible results would be obtained.

The factors which come into play in judging the appearance of the erased surface are without doubt the most difficult to evaluate from a purely objective point of view. It seems quite evident from the studies that have been made that the reflectivity measurements (R_∞ and R_0) and the low-angle gloss measurements are of importance in following certain changes in appearance which would be perceptible to the eye. A measurement of the changes in the reflectivity values of R_∞ and R_0 is an objective means for measuring the degree of discoloration and the order of magnitude of the change in opacity, respectively, caused by the erasure. The gloss values would be useful for judging the degree of polish or roughness developed during the erasure. In general, it was found that the appearance of a written character on the abraded surface of a paper having a gloss ratio greater than unity was superior to that of a similar character on a paper having a ratio less than unity. Changes in the appearance of the paper that were not detected instrumentally were those caused by the removal of cockle or of other surface markings on the paper.

On the basis of the observations made in the foregoing studies, it is believed that the writing quality of the abraded and unabraded surfaces might best be judged visually with the aid of pictorial standards. The lines ruled on the samples could be compared directly with a standard set of lines in a photograph displaying various kinds of writing quality. The Schur-Levy rotary pen used in this study operated satisfactorily, applying the ink in a reproducible manner; this pen would be well worth considering in the standardization of a method for the application of inked lines.

The function of the paper is an aspect of erasability that must be considered because of the specific properties that may be desired in the erasing quality of the paper and also because of the influence penciled, typed, and inked characters may have on erasability data. A difference in the depth of penetration of the ink or a difference in the depth of the grooves produced with typed or penciled characters would upset the ranking of papers insofar as ease of erasure (number of strokes to expunge the characters) and the opacity changes are concerned. A serious misranking on the basis of the gloss measurements would not be anticipated because of the small dependence of gloss on the depth of erasure in the sheet. Since inks were used exclusively throughout this study, no definite conclusions can be made, as yet, as to the relative effects on erasure of using inked, penciled, or typed characters. Further studies would be necessary to determine what such effects would be.

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Standard Drainage Time of Pulp for Insulating Board

TAPPI Suggested Method T 1002 sm-51

(THIS METHOD IS UNDER THE JURISDICTION OF THE STRUCTURAL FIBROUS MATERIALS COMMITTEE)

This method applies to the measurement of the drainage time of coarse, easily dewatered, insulating-board pulps. The apparatus of TAPPI Standards T 221 m and T 227 m, respectively, was designed for papermaking pulps that dewater more slowly than insulating-board pulps. As a result the apparatus loses maximum differentiation in the rapidly dewatering pulps used for insulating boards. Only by a major concentration of resistance to water flow at the fiber pad under test can the best differentiation be obtained, and even then it is none too great, particularly in the coarser fiber grades of the normal range of insulating-board pulps. For this reason a special apparatus has been designed.

APPARATUS

1. *Disintegrator for Stock Not in Slush Form.* The standard disintegrator described in detail in TAPPI Standard T 205 m, Forming Handsheets for Physical Tests of Pulp.

2. *Container.* A round metal container of 7-inch diameter and 10 inches high, with two handles near the top edge 180° apart. A mark is placed on the inside surface of the container at the 5000-ml. level as measured with water at 80 ± 5°F.

3. *Container Stirrer.* This is made up of a round metal plate, $^1/_{16}$ inch thick, with a 6-inch diameter, perforated at random with 18 holes each of 1-inch diameter that are well dispersed over the plate. A round metal rod or pipe 18 inches long is fastened at right angles to the center of the plate for a handle.

4. *TAPPI Standard SFMC Drainage Tester.* The completed drainage tester is shown in Fig. 1. A cylindrical brass base, *A*, has an outside diameter of 4 inches at the top and flares out at the bottom to a 5-inch diameter. The inside diameter at the top is 3 inches, which reduces to the 2-inch pipe, *F*, of the water leg. The top edge of the base is cut away on the inside surface to a diameter of $3\ ^9/_{16}$ inches for a depth of $^1/_4$ inch to form the screen ring seat.

The brass screen, brass screen ring, *H*, and rubber screen ring gasket seat in the recess in the base top. The screen ring, however, projects over the base top for about half its depth to the outside diameter of the base. The screen ring inside diameter is 3 inches, that of the part fitting into the recess in the base top 3.5 inches, and that of the part above the base top 4 inches. The overhanging part has a thickness of $^3/_{16}$ inch and the recessing part $^1/_4$ inch. Thus $^1/_{16}$ inch clearance in diameter is allowed between the screen ring and the base. A brass screen 4 inches in diameter with a 40 by 40 mesh and solid brass wire 0.010 inch in diameter is soldered to the top of the screen ring.

An adapter sleeve, *B*, slides down over the outside diameter of the base, *A*, and is shouldered inward in the inside diameter to a 3-inch diameter to rest upon a second rubber gasket, which in turn rests upon the screen. Thus the screen ring is rubber-gasketed above and below. Two locking pins 180° apart are provided which mesh with sloped recesses in the adapter sleeve to give a locking of the adapter sleeve to the base by a turn of about 10° of the sleeve. The turn of the sleeve causes the sleeve to ride downward slightly, developing pressure for a water seal at the gaskets.

Fitted into a recess cut in the upper edge of the adapter sleeve *B* is a glass cylinder, *C*, of single thickness, 3 ± $^1/_{64}$ inches in diameter and approximately 19 inches long. A rubber gasket cushions the cylinder end where it seats in the adapter sleeve. A brass collar, *E*, is provided at the top of the glass cylinder, recessed and gasketed to hold the cylinder in a way similar to the adapter ring. Four tie rods, *D*, run between the top coller *E* and the adapter sleeve *B*, which are loosely fitted in the collar and threaded into the adapter ring. The tie rods when tightened hold the assembly of the collar, glass cylinder, and adapter ring tightly together and provide pressure on the gaskets for watertight joints. The glass cylinder has two short, etched lines 2.5 inches above the screen surface, *L*, and 180° apart, to mark the end of the test. A second pair of short etched lines are made near the top of the glass cylinder to show the level of 1800 ml. of water at 80 ± 5°F. (about 15.5 inches). These marks establish the beginning point for the test.

A 2-inch drainage pipe, *F*, quick-opening valve, *J*, and trap, *K*, provide a water leg of 36 ± $^1/_8$ inches and control the test. The large pipe diameter (2 inches) compared to the cylinder diameter (3 inches) reduces frictional losses other than at the fiber pad. A water inlet and control valve, *I*, are provided to fill or flush

This method is suggested by the Standards Committee as being the most suitable to date. It is *not*, however, a TAPPI Standard. Criticisms are earnestly requested and should be sent to R. G. Macdonald, Secretary, Technical Association of the Pulp and Paper Industry, 122 E. 42nd St., New York, N. Y.

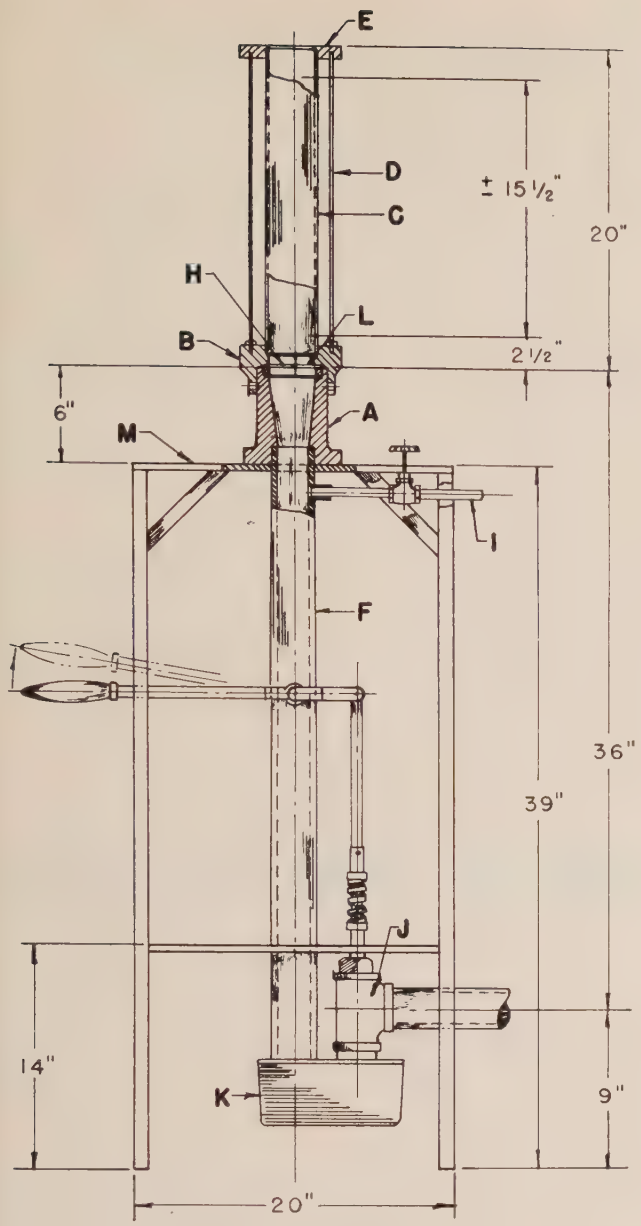

Fig. 1. TAPPI Standard SFMC Drainage Tester

the drainage tester. A table, *M*, is used to support the drainage tester and for convenience of operation.

5. *Drainage Tester Stirrer.* This has as a handle a $^{3}/_{16}$-inch metal rod, 24 inches long, and a 1.5-inch diameter disk, $^{1}/_{16}$ inch thick, fastened at right angles to the handle at one end.

6. *Miscellaneous Equipment.* Four 1000-ml. glass graduates, a 250-ml. beaker, a stop watch, scales, and an oven will be required during the test. Any such laboratory equipment of suitable size, quality, and accuracy will be satisfactory.

TEST SPECIMEN

Sampling shall be done so that the test specimen is representative of the entire amount of pulp under examination. The quantity of pulp for one standard drainage time determination will be about 150 grams dry weight, including provision for a moisture determination and for a suitable excess of pulp.

Slush pulps shall be dewatered with care to avoid an appreciable loss of fines. A screen no coarser than approximately 60 mesh with a wire diameter of No. 34 B & S Gage shall be used. A finer screen may be used if desired. A TAPPI Standard Sheet Machine (T 205 m) or a Williams Sheet Mold is satisfactory for dewatering pulps.

Moisture Determination

Weigh out an amount of normal-moisture or dewatered pulp equivalent to 75 to 100 grams moisture-free and dry to constant weight at 100 to 105°C. Calculate the moisture content.

PROCEDURE

Calibration of Drainage Tester

An occasional check of the "zero" (water only) reading should be made by filling the drainage tester with water at 80 ± 5°F. to the top cylinder mark twice and measuring the time required for the second filling to drain to the bottom cylinder mark when the release valve is wide open. The time interval should be 1.5 seconds. If over 2 seconds, check the screen and valve for cleanliness. A new screen should be available for replacements.

Number of Tests

A Standard Drainage Time determination shall be the average of three tests. If a substantial agreement, as defined below under Report, is not obtained within the three tests, a fourth test shall be made. If the fourth test does not establish an agreement, the standard drainage time determination shall be completely rerun.

Preparation of Pulp

If the pulp to be tested is dry, or substantially dry, soak in cold water until thoroughly wet. When wet through, slush the required amount of pulp in the standard disintegrator. If the pulp is dewatered from a slush form, the disintegrator need not be used. Tests should be made on slush-form fiber whenever possible, as results obtained on dry or substantially dry fiber are not as reliable.

Weigh out pulp sufficient for five tests, the equivalent of 53.0 grams dry weight. This will provide 1.5 grams of dry fiber per square inch of screen, the quantity of fiber which has been found to produce a proper pad thickness in the test. Place the pulp in the container and add water at 80 ± 5°F. to the mark on the container (4947 ml. with allowance for moisture in the pulp).

Making Drainage Time Test

Mix the pulp thoroughly with the container stirrer, taking care that air is not stirred into the pulp. *While continuing the stirring*, measure out four 1000-ml. samples by dipping pulp with a 250-ml. beaker from the container into four graduates. Each dipping of pulp shall be placed in sequence in the four graduates beginning with the first graduate and returning to it after placing a dipping in each of the other three graduates. Continue dipping until each graduate is filled to the 1000-ml. mark. Sufficient pulp has been prepared to leave an excess of 1 liter of stock even if four tests are necessary. Utilization of stock to empty the container would result in variations in consistency of the stock measured out.

The drainage tester shall have been previously prepared by filling the water leg with water from tap-water inlet valve until the water level is a few inches above the screen. The rate of filling with tap water should be slow, so that the level approaches the screen slowly; otherwise air bubbles may be trapped beneath the screen and the presence of air in any part of the water leg will lead to erratic results. Next fill the drainage tester with water at 80 ± 5°F. and, after a few moments, drop the level to the bottom mark on the cylinder by slowly opening the release valve. The tester parts are warmed by the prefilling with warm water. Now pour the 1000-ml. sample into the drainage tester and add water at 80 ± 5°F. to bring the final level to the top mark on the cylinder. Mix the stock thoroughly with the proper stirrer, using long deliberate strokes. (*See* Note 1.) At the same time, suspend a thermometer in the stock in the cylinder of the drainage tester and read the temperature to the nearest °F. When the pulp in the drainage tester cylinder is thoroughly mixed, remove the stirrer and within 5 seconds open wide the release valve, starting the stop watch at the same time. When the level of the stock has fallen to the bottom mark (*see* Note 2), stop the watch. Continue holding open the release valve until free water has drained from the fiber mat, then close the valve. Remove the cylinder, lift the pad from the screen, and dry to constant weight at 100 to 105°C. as a check on the original moisture determination. The dry pad weight shall check with ±3% the 10.6-gram objective weight, i.e., it shall be 10.3 to 10.9 grams.

Notes: (1) Occasionally a certain type of fiber will show a tendency to float to the water surface during the interval that the test is in progress. "Floating out" will cause erroneous results and indicates air on the fiber. The air can be removed by subjecting the test stock to a vacuum. Care must be taken that fines are not lost through foaming when the vacuum is applied.

(2) The bottom mark on the drainage test cylinder at a point high enough to record the water level before the pad becomes dewatered is used as the end point rather than complete drainage through the mat because it is a definite end point and not subject to the judgment of the operator as is the point at which a mat becomes dry.

REPORT

The Standard Drainage Time shall be the average in seconds of three drainage time tests, with an agreement as noted below. It shall be reported to the nearest 0.5 second for results from zero to 50 seconds and to the nearest second for results above 50 seconds.

To obtain the standard drainage time three drainage time tests shall be made. If the average of the three tests is 50 seconds or less and in these three tests the maximum deviation from their average is not over ±3%, the standard drainage time shall be taken as the average time in seconds of the three tests. If the maximum deviation from the average is greater than ±3%, a fourth drainage time test shall be made as provided for in the procedure. From the four drainage time results three shall be selected with the least deviation from their average. If the three selected tests have a maximum deviation from their average not over ±3%, the standard drainage time shall be taken as the average time in seconds of the three selected tests.

If the four drainage time tests fail to provide three tests with the required maximum allowable variation, all test results shall be discarded and the test rerun.

If in the above procedure the average of the first three tests is greater than 50 seconds, then the procedure remains unchanged but the tolerances become ±5% in all instances.

ADDITIONAL INFORMATION

Designing of apparatus for this procedure was undertaken only after comprehensive tests and analyses, not only of the TAPPI instruments but of all known apparatus designed for the purpose of drainage testing. The insulating board industry seldom uses presently available drainage testing apparatus because of lack of suitability and because no procedure or testing equipment has heretofore been standardized for insulating board pulps. It is hoped that the establishment of a standard procedure and apparatus of a proper design for the insulating board industry will eliminate the present confusion and provide more accurate and uniform pulp control.

It is probable the apparatus here described will find application with pulps other than those used for insulating board. Any pulp where dewatering takes place too rapidly to provide a suitable differentiation in existing instruments can be better evaluated in the apparatus of this method.

Paper and Packaging Specifications

U. S. GOVERNMENT SPECIFICATIONS

Following is information from B. W. Scribner, National Bureau of Standards, Chairman, Technical Committee on Paper and Paper Products, Federal Specifications Board, on Federal specifications of recent issue:

Federal Specifications Index

A revision of the Federal Specifications Index, revised to Jan. 1, 1951, has been issued under the new title, "Federal Specifications and General Services Administration Specifications Index." This and Federal specifications may be obtained on application accompanied by postal note, money order, coupon or cash to the Superintendent of Documents, Government Printing Office, Washington 25, D. C. The price of the Index is 35 cents.

New Military Index of Standards

A complete index of specifications and standards of the Department of Defense has been compiled and will soon be available to the public, according to Col. A. E. Mickelsen, chief, Munitions Board Standards Agency, Department of Defense. The listing entitled "Military Index" consists of four volumes. The first volume indexes the Munition Board's standards as of April 1, 1951, and should be available through the Government Printing Office within the next few days.

Volume 3 of the index lists the Navy Department specifications as of March 1, 1951, and is currently available. Army specifications are in Volume 2 and Air Force standards in the fourth volume. Col. Mickelsen indicated that monthly supplements of the "Military Index" would be issued.

Standardization in the Department of Defense, according to Col. Mickelsen, is the responsibility of three groups: the Joint Chiefs of Staff, the Research and Development Board, and the Munitions Board.

He called attention to the new series called "MIL Specifications," pointing out that it is replacing the work of the Joint Army and Navy Specifications Board (JAN Specifications). A uniform format is being used in writing all of the specifications, Col. Mickelsen said. Basic purposes of the standardizations, according to Mickelsen, are to increase production, conserve material, and manpower resources, and decrease cost of production.

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Calendar of TAPPI Meetings

NATIONAL

Fundamental Research Conference, Institute of Paper Chemistry, Appleton, Wis., September 19–21, 1951

Alkaline Pulping Conference, John Marshall Hotel, Richmond, Va. September 26–28, 1951
General Chairman—Henry Vranian, Chesapeake Corp., West Point, Va.
Program Chairman—R. R. Fuller, Gulf States Paper Co., Tuscaloosa, Ala.

Sixth Engineering Conference of the Pulp and Paper Industry, General Oglethorpe Hotel, Wilmington Island, Savannah, Ga., October 15–18, 1951
General Chairman—George H. Pringle, Mead Corp., Chillicothe, Ohio

LOCAL SECTIONS

All local sections will resume meetings in September or October.

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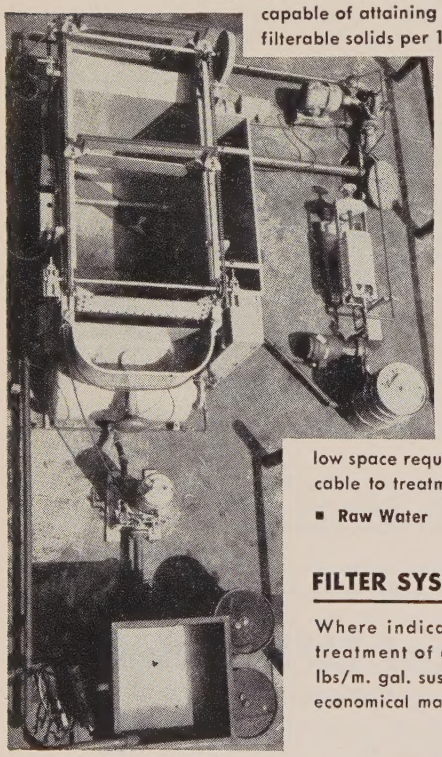

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INDEX TO ADVERTISERS

American Cyanamid Co. (Industrial Chemicals Div.) ... 23 A
American Polymer Corp. ... 107 A
American Resinous Chemicals Corp. ... 98 A
Ansul Chemical Co. ... 106 A
Antara Products Div. (General Dyestuff Corp.) ... 21 A
Appleton Machine Co. ... 6 A
Appleton Wire Works, Inc. ... 61 A
Armstrong Machine Works ... 69 A
Babcock & Wilcox Co. ... 7 A
Barrell Co., Wm. L. ... 81 A
Bauer Bros. Co. ... 102 A
Beloit Iron Works ... 1 A
Bird Machine Co. ... 55 A
Black-Clawson (Shartle & Dilts) ... 4 A
Brown Co. ... 10 A
Buckman Laboratories, Inc. ... 4th Cover
Buffalo Electro-Chemical Co., Inc. ... 15 A
Bulkley, Dunton Pulp Co. ... 124 A
Cabble Excelsior Wire Mfg. Co., Wm. ... 91 A
Chicago Bridge & Iron Co. ... 45 A
Clark-Aiken Co. ... 85 A
Combustion Engineering-Superheater, Inc. ... 17 A
Corn Products Refining Co. ... 100 A
Curlator Corp. ... 57 A
Dicalite Div. (Great Lakes Carbon Co.) ... 99 A
Dorr Co. ... 41 A
Dow Chemical Co., The ... 47 A
Draper Brothers Co. ... 36 A
Du Pont de Nemours & Co., E. I. (Dyestuffs) ... 3rd Cover
Du Pont de Nemours & Co., E. I. (Pigments) ... 51 A
Ebasco Services, Inc. ... 108 A
Farrel-Birmingham Co., Inc. ... 39 A
Foxboro Co., The ... 8 A
Geigy Co. (Dyestuff Div.) ... 110 A
Gilbert Associates, Inc. ... 35 A
Goodyear Tire & Rubber Co. (Chemical Div.) ... 2 A
Gruendler Crusher & Pulverizer Co. ... 97 A
Gurley, W. & L. E. ... 111 A
Hercules Powder Co. ... 2nd Cover
Hermann Manufacturing Co. ... 50 A
Hubinger Co., The ... 105 A
Improved Paper Machinery Corp. ... 93 A
Infilco Incorporated ... 29 A
Jackson & Church Co. ... 11 A
Johnson Corp., The ... 109 A
Johns-Manville (Transite Div.) ... 27 A
Johns-Manville (Celite Division) ... 49 A
Jones & Sons Co., E. D. ... 75 A
Kelco Co. ... 73 A
Lobdell United Co. ... 77 A
Mallinckrodt Chemical Works ... 111 A
Merritt-Chapman & Scott Corp. ... 79 A
Monsanto Chemical Co. ... 31 A
Murray Manufacturing Co., D. J. ... 16 A
National Aluminate Corp. ... 43 A
National Forge & Ordnance Co. ... 109 A
Nopco Chemical Co. ... 9 A
Paper & Industrial Appliances, Inc. ... 104 A
Penick & Ford, Ltd., Inc. ... 108 A
Philadelphia Quartz Co. ... 101 A
Prior Chemical Co. ... 48 A
Pusey & Jones Corp. ... 52 A
Rice Barton Corp. ... 83 A
Rohm & Haas Co. ... 25 A
Ross Engineering Corp., J. O. ... 37 A
Sandy Hill Iron & Brass Works ... 67 A
Shuler & Benninghofen ... 95 A
Solvay Sales Div. (Allied Chem. & Dye Corp.) ... 59 A
Soundview Pulp Co. ... 63 A
Sprout, Waldron & Co., Inc. ... 87 A
Stebbins Engineering & Mfg. Co. ... 96 A
Sveen-Pedersen Sales Corp. ... 33 A
Swenson Evaporator Co. (Whiting Corp.) ... 22 A
Torrington Co., The (Bantam Bearings Div.) ... 3 A
Tracerlab, Inc. ... 89 A
Vanderbilt Co., R. T. ... 13 A
Wallace & Tiernan Co., Inc. ... 65 A
Wallerstein Co. ... 110 A
Western Precipitation Corp. ... 71 A
Westinghouse Electric Corp. ... 18 A–19 A

PROFESSIONAL SERVICES

American Defibrator, Inc. ... 123 A
Bjorksten Research Laboratories ... 123 A
Ferguson Co., H. K. ... 123 A
Knowles Associates ... 123 A
Main, Inc., Chas. T. ... 123 A
Myers & Addington ... 123 A
O'Donoghue, Roderick ... 123 A
Paper and Pulp Testing Laboratories ... 123 A
Pfeifer & Shultz ... 123 A
Sirrine Co., J. E. ... 123 A
Stadler, Hurter & Co. ... 123 A
Wierk, Frederick ... 123 A

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